DEFENSE SYSTEMS MANAGEMENT COLLEGE

Systems Acquisition Manager's Guide for the use of MODELS AND SIMULATIONS

Report of the
DSMC 1993-1994
Military Research Fellows

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DEDICATION

In this, the fiftieth anniversary year of the Normandy invasion, the DSMC Military Research Fellows dedicate this guidebook to all who have faithfully served the Armed Forces of the United States of America, and to their families for their support.

ACKNOWLEDGEMENTS

This guidebook is the result of an 11-month Military Research Fellowship program sponsored by the Defense Systems Management College (DSMC) and Under Secretary of the Air Force, Acquisition (SAF/AQ) and funded by the Defense Modeling and Simulation Office (DMSO).

"The advantage we had in DESERT STORM had three major components. We had an advantage in people, an advantage in readiness, and an advantage in technology."

Dr. William J. Perry's (as Deputy Secretary of Defense) remarks to the National Contract Management Association, Washington, DC, November 18, 1993

"We need to preserve that part of the industrial base which will give us a technological advantage, but we have to do it at a reduced cost and increased efficiency in procurement."

Dr. William J. Perry's (as Deputy Secretary of Defense) remarks to the National Contract Management Association, Washington, DC, November 18, 1993

"Simulation and modeling technology can be applied to every major DoD weapon development program to reduce design and production cost, improve performance, improve diagnostics and maintenance, assist in better and faster training of personnel, and improved command and control on the battlefield."

Mrs. Colleen Preston's (Deputy Under Secretary of Defense Acquisition Reform) Testimony to Congress, (March 1994)

NOTICE

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PREFACE

This guidebook represents the combined efforts of three military Research Fellows participating in an 11-month Senior Service College Research Fellowship program sponsored by the Under Secretary of Defense for Acquisition and Technology (USD(A&T)). The fellowship program has two purposes: first, to provide professional and military education for selected officers from the Army, Navy and Air Force; and second, to conduct research in a subject of vital interest to the U.S. defense acquisition community. In keeping with its role as the center for systems management education in the DoD, the Defense Systems Management College (DSMC), cooperating with the Harvard University Graduate School of Business, provided the means for conducting this study. The fellowship program included a 12-week resident Program for Management Development (PMD) course at Harvard University.

Our research effort was funded by the Defense Modeling and Simulation Office (DMSO). The focus of the research was to develop and produce a guidebook on modeling and simulation (M&S) as it relates to systems acquisition management. The book will be broadly distributed to policy makers, military departments, government offices, research centers, libraries and academic institutions.

The purpose of this research guidebook is to provide the reader with current DoD initiatives, forthcoming policy and guidance, and identification of newly formed organizations in M&S. This book will provide a better understanding of how models are developed, applied in simulations and their value in analysis; and more importantly, it provides a quick reference for the application of these tools in the development of weapon systems. Also, this guidebook offers lessons learned from current acquisition managers, advice on management practices, points of contact (POCs) and how to access M&S data bases.

During the first month of the research effort time was spent initiating background research, developing a research plan and consulting with the DSMC faculty. The next 12-weeks were spent attending the Harvard PMD course. Upon our return to DSMC, we immersed ourselves in this research effort.

As we began our research, we were quickly overwhelmed by the amount of information on M&S with two exceptions; M&S documented history and the role of M&S in acquisition. Since our topic was preselected and funded by DMSO, we focused our efforts to provide a consolidated guidebook for M&S in acquisition with little attention to history.

To start with, even a basic understanding of terms is needed. We will begin here by providing definitions of model and simulation. A *model* is a physical, mathematical or otherwise logical representation of a system, entity, phenomenon or process. The definition of *simulation* is twofold: a method for implementing a model over time; and a technique for testing, analyzing or training in which real-world systems are used; or where real-world and conceptual systems are reproduced by a model.

The scope of this effort was another difficult aspect. What resulted, with the assistance of members from the Acquisition Task Forces on Modeling and Simulation (ATFM&S), was to provide a quick reference type guide.

Our task was to produce this guidebook with a focus on *Program Management.* Difficulties arose in how to approach the DoD's Systems Acquisition Process while weaving M&S into the process. The complexity was compounded because the Systems Acquisition Process is comprised of three separate but interfacing systems: the requirements generation system; the acquisition management system; and the planning, programming and budgeting system (PPBS).

The program management world includes all three systems. However, the only system that presently uses the entire realm of M&S is the acquisition management system. Therefore, this guidebook focuses on the acquisition system with some discussion of the requirements generation system and the PPBS. For a very good, quick tutorial on the DoD systems acquisition process, refer to the book *Introduction to Defense Acquisition Management,* by Joseph H. Schmoll.[1]

Readers pressed for time may wish to proceed directly to Chapter Seven for Modeling and Simulation Management Considerations and Chapter Eight for The Future State of Modeling and Simulation and Best Practices. For others, Chapter One provides an introduction to the acquisition environment and applicability of M&S. Chapter Two provides general information about M&S. Chapter Three provides a quick reference for policy and guidance. Chapter Four contains a more detailed discussion regarding The Classes of Models and Simulation. Chapter Five provides a view of M&S Applications from two different aspects—across the acquisition life cycle and in support of specific acquisition activities. Chapter Six provides managers with information on some of the issues in the use and management of M&S. The Appendices are provided for expanded information about each individual Service, as well as additional M&S information sources.

We owe our gratitude to many people. During this research effort, we have been genuinely thankful for their help. The faculty and staff at Harvard University and DSMC were extremely helpful with their encouragement, insight and support. A number of people have been particularly helpful: Dr. Adelia Ritchie, Dean of the Research, Consulting and Information Division at DSMC, served as our mentor providing helpful advice and guidance throughout this research effort. Special thanks to Mr. Dan Chapla, CDR John Farlin, LtCol Wayd Weber, LTC James Huskins, Mr. Chuck Cochrane, Mr. Bill Motley, CDR James Grayson and Mr. Joel Manary of the DSMC faculty for their valuable insights and for reviewing our document. We owe our gratitude to the DSMC librarians for their outstanding support throughout our effort; as well as to the DSMC Press staff for their many hours of work to make this a quality product.

This document would not have been possible without a few key players outside DSMC. A special thanks to: Major Joe Bond, DMSO, for all his support from funding to consolidation of survey information to coordination of ATFM&S activities; Mr. Ed Muendel and Mr. Gil Brauch, Logistics Management Institute (LMI), for their consolidation of survey information, advice for site visits to Navy and Army installations, and candid comments during our reviews; Mr. Chip Ferguson and Mr. Jim O'Looney, Science Applications International Corporation (SAIC), for their consolidation of survey information, advice for site visits to Air Force locations, and for their candid comments during our reviews; and Dr. Stuart Starr, the MITRE Corporation, for his insight into technology. Additionally, the efforts of Mr. Ron Cross, HQ TRADOC, Ms. Trell Hudson, MARCORSYSCOM, Dr. Robert Smith, NAWCWPNS, Mr. David Berry, SPAWAR 312-3, Ms. Sylvia Diaz, HQDA OASA(RDA), Mr. Michael Rybacki, USALEA, LtCol Mike Baum, Joint Staff/SPED (J-8), LtCols Cheryl Balombini and Mike Hathaway, HQ USAF/XOM, LtCol Harry Mandros, ACC/DRM, Maj Dean Fish, MCMSMO and Maj Steve Chimelski, HQ AFMC/XRX were essential in pulling this document together.

The Research Fellows extend a special note of appreciation to Ms. Joan Sable, DSMC Military Research Fellowship Coordinator. Ms. Sable's efforts were invaluable in this effort; managing the budget, ensuring adequate administration support, and coordinating and facilitating the document reviews. She knew where the "show-stoppers" were and kept our project on track, on budget and on schedule. Ms. Sable was tireless in her efforts to ensure that we were free to concentrate our efforts toward providing a document that would be useful and meaningful to the reader.

There are many others that deserve recognition, but in fairness to all, there are too many to mention. The three research fellows would like to thank all of those interviewed. We hope this guidebook is as helpful to you as you were to us—thank you.

ENDNOTES

[1]DSMC Press, March 1993, GPO no. (ISBN 0-16-041725-2)

1

INTRODUCTION

In June 1991, the Deputy Secretary of Defense approved a plan to strengthen the use of modeling and simulation (M&S). He also designated the Under Secretary of Defense for Acquisition and Technology (USD(A&T)), formerly the USD(A), as responsible for "strengthening the use of modeling and simulation in joint education and training, research and development, test and evaluation and operation and cost analysis."[1]

In June 1992, the Institute for Defense Analyses (IDA) published a report titled "A Review of Study Panel Recommendations for Defense Modeling and Simulation."[2] IDA reviewed 179 recommendations made by 25 separate study panels, over a 16-year period, concerning defense M&S. The Defense Modeling and Simulation Office (DMSO), using this document as a conceptual foundation, reviewed and classified the recommendations and set off to plan for and implement those that provided for new and extended applications for M&S. The DMSO especially focused on systems acquisition and test and evaluation (T&E). The initiative instituted by the Deputy Secretary of Defense is now referred to as the Defense Modeling and Simulation Initiative.

Some key conclusions drawn from the IDA review were:

- Specific areas, such as the architectural issues of interoperability and specification of standards, and the life-cycle support of defense models and simulations, deserve more attention and support.

- There are many areas to which defense M&S either should be applied anew or extended, especially those associated with systems acquisition.

- There are substantial needs and opportunities for improving management and coordination of defense M&S activities.

In a DoD Inspector General (IG) audit on M&S, 1 Mar 1993,[3] the following findings highlighted many shortcomings in DoD's ability to effectively and efficiently utilize models and simulations:

1. DoD lacks adequate M&S policy;

2. Most M&S applications lack verification, validation and accreditation (VV&A);

3. Significant effort is devoted to developing "stand alone" models with no intent to reuse—costly duplication;

4. Absence of a central library resource contributes to redundant investment; and

5. FY93 DoD expenditures were estimated to be from $1.3 to $1.6 billion—consolidation of effort could have saved an estimated $800 million.

The philosophy of M&S evolves around three overlapping areas: operational planning, acquisition and training. Operational planning helps utilize our equipment and forces to best achieve our national objectives and identify new requirements. Acquisition provides the items, systems and technology the commander can use to support operational planning. Finally, training teaches our people how to employ forces, use systems and apply technology provided through acquisition to support operational planning. The use of M&S provides a comparatively inexpensive way to plan, acquire and train.

Throughout the DoD there is an increasing interest in addressing the problems identified by the DoD IG. The formation of the Acquisition Task Force on Modeling and Simulation (ATFM&S), sponsored by the DMSO, represents a commitment of the DoD to find ways to optimize and fully utilize hardware and software tools and data bases available to all DoD agencies, particularly program managers (PMs).

1.1 PURPOSE

The purpose of this guidebook is to assist the acquisition community, by providing information on DoD policy regarding M&S, identifying the existing M&S capability and describing how M&S can be applied throughout the acquisition cycle. Understanding these topics gives PMs the opportunity to pursue dual-use technologies, including commercial-military integration; allows for faster and lower cost manufacturing and complements operational test and evaluation (OT&E).[4]

1.2 METHODOLOGY

This project was approached by focusing on our target customers, the program managers, and what would help make their job easier.

This guidebook was developed using a modified approach to designing a technical document. The in-process reviews (IPRs) (sometimes called *murder boards*) were conducted, first by the fellows, then by the faculty at DSMC. Additional IPRs were scheduled with selected PMs and representatives from the ATFM&S and Service M&S representatives, at DSMC prior to publishing.

This guidebook was based on the current systems acquisition process and discusses the capabilities of using M&S to enhance the efficiency of that process. Since the use of models and simulations is functionally oriented, this document retains its applicability to any future modification of the acquisition process.

At the front of this effort with DMSO funding, the Logistics Management Institute (LMI)—with support from the Science Applications International Corporation (SAIC) and the MITRE Corporation—sent surveys to selected ACAT I and ACAT II program offices. These surveys were used to determine what models and simulations exist; how they are used, managed and analyzed; and what are the “opportunities” and “pitfalls” surrounding their use. The contractors consolidated the information and provided it to the Research Fellows and the ATFM&S. Using the surveys as a starting point, data were gathered from product centers, research centers, contractors, using commands, test centers, and training and simulation conferences by site visits and telecommunications.

1.3 SPECTRUM OF MILITARY MODELING AND SIMULATION

The using community of models and simulations is broad; extending from operators of weapon systems all the way to analysts in laboratories. Full comprehension of M&S terminology is difficult—this document will not make the reader an expert, but it will aid in the reader's understanding of this very complex topic.

There have been several discussions about appropriate definitions and use of terms throughout the DoD; this book is no exception. However, after a review of this guidebook readers will have a solid foundation for discussing and improving their knowledge of M&S.

There are many ways to characterize M&S. The spectrum of M&S includes broad types, classes, hierarchy and applications (functional areas). The three general types of models are: wargaming; training; and acquisition.

Wargaming models range from single engagement (one-on-one) to joint theater level campaign operations. Training models range from single template instructional systems to complex virtual reality simulations. Acquisition models range from physical level phenomenon models through engineering component design tools to models of systems-in-the-end-use-environment.

Classes of models and simulations include virtual, live and constructive. These are described in Chapter 4.

The hierarchy of models (usually depicted as a pyramid) represents the standard building block approach for interfaces within the modeling world, indicating an ever increasing complexity from the bottom up. This hierarchy is also discussed further in Chapter 4.

Applications of models and simulations are generally viewed from the functional perspective, which are categorized as education, training and operations; research and development; test and evaluation; analysis; and production and logistics. Applications of models and simulations to specific activities is further discussed in Chapter 5.

This brief insight is intended to whet the readers appetite and show how M&S is a vital part of the DoD systems acquisition process.

The advances being made in computer hardware and software technologies are providing increasing opportunities to leverage M&S applications across traditional functional lines. For instance, some programs are beginning to use engineering level system models in virtual combat environments normally used by the training community. Properly done, this cross-functional application allows for the early evaluation of design trade-offs on overall combat performance. Using existing combat simulations has two payoffs:

1. Consistency of evaluation perspective between the acquisition and user communities; and

2. Reduction of duplication and overlapping simulation development efforts.

1.4 Assumptions

The following assumptions provide a common starting point to present M&S applications to the systems acquisition process.

- The acquisition community is operating under the acquisition process established by DoDD 5000.1, *Defense Acquisition* and DoDI 5000.2, *Defense Acquisition Management Policies and Procedures*, both dated February 1991.

- DoDD 5000.59, *DoD Modeling and Simulation (M&S) Management* definitions are accepted throughout the DoD as the correct and standard definitions.

- The reader already has a basic understanding of the systems acquisition process and how its functional elements work.

- The reader knows very little about M&S.

- The reader is interested in knowing the following:

  — What people are talking about when referring to M&S being used in acquisition.

  — How to explain the use of M&S tools in support of a particular program.

  — How to make sure the right models and simulations are being used.

  — How to interpret what comes out of M&S.

  — How to assure the use of M&S is controlled with respect to a particular program.

  — Where to go to get help.

- This guidebook talks to acquisition programs under the DoD 5000 series versus the DoD 8000 series, but the concepts presented herein apply equally as well to software acquisition.

1.5 Acquisition Environment

The DoD is faced with a new world-wide order of political, economic and military affairs. National security has many new challenges. The Government is committed to providing a strong force capable of effectively deterring threats to the United States and its allies.

The downsizing of the military, the reduction of available resources and a process that takes more than a decade to exploit advancing technologies and meet evolving requirements, indicate the need for improved efficiencies and process improvement.

1.5.1 Existing Process

The DoD systems acquisition process evolved over the years to ensure fair treatment to contractors; prevent fraud, waste and abuse; keep a government check on its authority over and demand on suppliers; and enhance socioeconomic objectives. The final acquisition process ended up being cumbersome; taking excessively long to meet warfighter requirements. In addition, the administra- tive process drove DoD costs higher and higher.

1.5.2 Future Acquisition

The challenge is to procure state-of-the-art technology and products, rapidly, from reliable suppliers who utilize the latest manufacturing and management techniques; assist United States companies now predominantly dependent on DoD business to transition to dual-use production; aid in the transfer of military technology to the com-

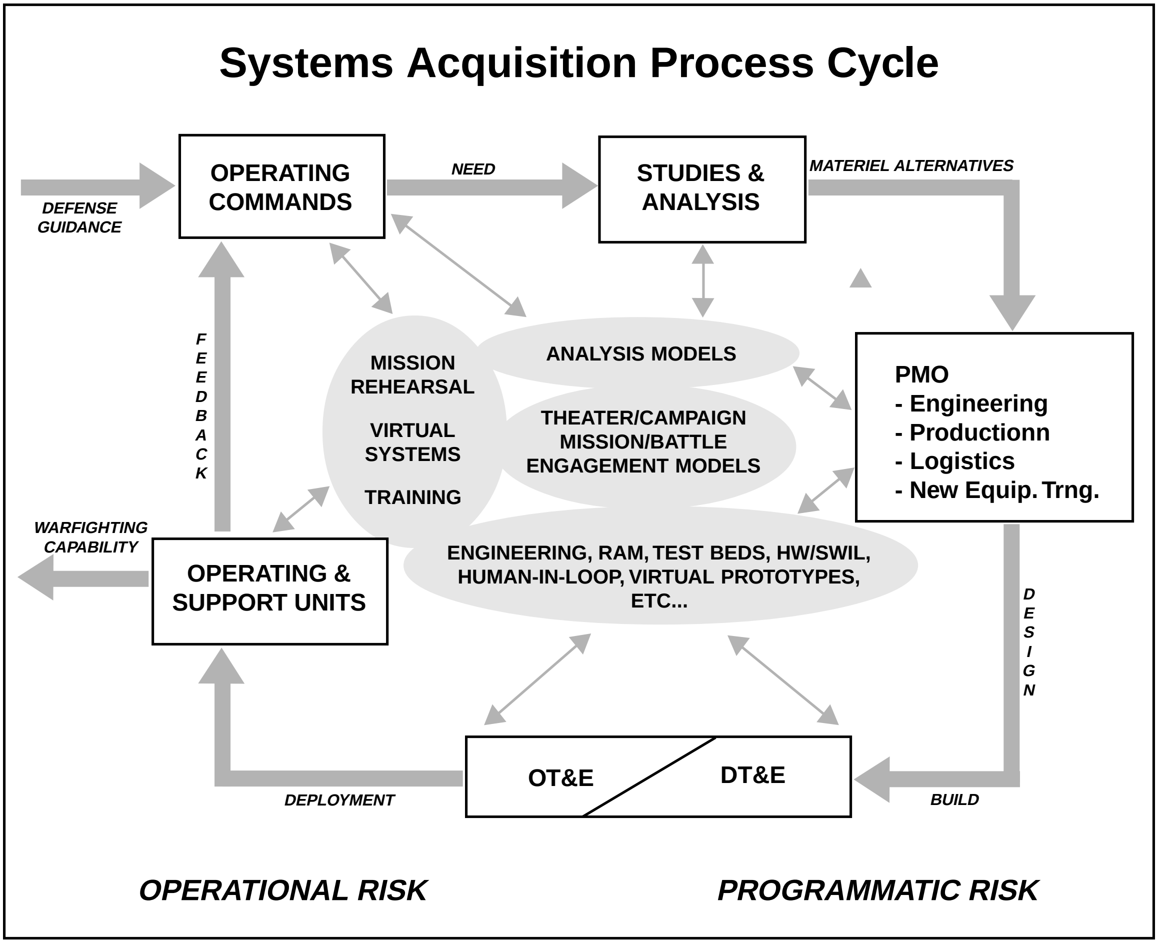


Figure 1-1. Systems Acquisition Process Cycle

mercial sector; and preserve defense-unique core capabilities.

There are many pros and cons in the power of M&S that should be tempered with a healthy dose of reality. All acquisition problems will not be solved by M&S. However, M&S usage is the key ingredient to success in today's environment.

The risk associated with the acquisition process of today can be minimized with proper planning, use and understanding of models and simulations. For example, in a statement to the U.S. Senate Subcommittee on Federal Services, Post Offices and Civil Service, March 22, 1994, the DUSD(AR) stated, "simulation offers the potential of a cheaper and quicker way to find failure modes than does field testing."[5]

1.6 Models and Simulations in Acquisition

Models and simulations are viewed as a potential answer to many of DoD's systems acquisition process problems.

Models are generally used to prove concepts. This can be anything from a mathematical calculation to building full-scale replicas and submitting them to controlled environments. An underlying reason for using models and simulations is to reduce risk.

Risk reduction is the unifying concept throughout the entire systems acquisition process. It is very logical to view models and simulations as tools to minimize risk to cost, schedule, performance and supportability for the PM. From this viewpoint the *value added* of models and simulations can be communicated.

An explanation of what risk means in the acquisition system is needed at this point. When a system is fielded (operational), it is put there to meet a particular requirement based on a need. The system's ability to meet the mission requirements is continually evaluated. As the system becomes outdated, the risk associated with the system's ability to accomplish the mission increases. A risk assessment is conducted to determine if the mission can be accomplished by changing the use(s) of the system (i.e. tactics); modifying the system; or acquiring a new system. Once the level of risk is at the point where a major modification or a new system is needed, the operational risk, through requirements documentation is translated into programmatic risk and becomes shared with the acquisition community.

The acquisition community receives direction to provide a system that satisfies requirements evolved from the mission need. The cost, schedule, performance and supportability risks associated with the acquisition process are inherent. The acquisition community helps find the best contractor, manages the development and reports progress up through the chain to aggressively provide the operational community a system to meet its need.

Since time and resources are limited, this usually creates a situation where trade-offs must be made frequently using information generated by models and simulations to get the system operational at an acceptable performance level. This completes the systems acquisition process cycle. Figure 1-1 illustrates this cycle.

Why make this trip around the acquisition risk cycle? We do it to help clarify the need to use M&S to minimize risk through proper use in the systems acquisition process.

1.7 Objective

The objective of this guide is to provide a reference for acquisition managers which describes M&S policies, types of models and simulations, applications, and key technical and management issues. This guidebook is intended for use by program management offices (PMOs), acquisition support agencies, policy makers, military departments, government offices, research centers, libraries, industry and academic institutions. It should enable the manager to make better use of models and to better understand the results.

ENDNOTES

1. Deputy Secretary of Defense Memorandum, June 21, 1991.

2. IDA Document D-1161, June 1992.

3. DoD IG Audit Report No. 93-060, "Duplication/ Proliferation of Weapons Systems' Modeling and Simulation Efforts Within DoD", March 1, 1993.

4. Extract from John M. Deutch, USD(A&T), in his Testimony on Defense Reinvestment and Conversion Programs, May 4, 1993.

5. Colleen Preston, Statement to U.S. Senate Subcommittee, March 22, 1994.

2

BACKGROUND

The word *model* brings to mind several preconceived mental descriptions. Some remember the plastic pieces of an airplane, car or ship; all connected in an orderly fashion to be pulled apart, assembled, trimmed and sometimes painted. Others may remember watching an old war movie when the maneuver plans were drawn in the dirt; or as elaborate as a wood and metal scale model of a Nazi Germany's officer recreation and recovery facility used for mission rehearsal. There are many different descriptions and definitions of a model throughout the DoD.

Since World War II, technology has advanced at an ever increasing rate. This explosion of technology is moving faster than products can be acquired by the acquisition community. With technology, we can accomplish what was considered five years ago to be impossible. With the utilization of microproces- sors, several new spin-off technologies are popping up. These technologies range from an internetted nervous system type communication link of satellites, under sea and land fiber optic networks to customized biological organisms used to eat ocean oil spills.

This explosion is a dream come true for many. Virtual reality (an interactive, computer-generated or synthetic environment) for example is significantly changing our lives; entertainment, work, learning, travel and communications are all incorporating virtual reality. Information is being moved versus people.

Benefits are also being gained by utilizing virtual prototypes, computer based simulation of systems with a degree of functional realism. For example, virtual prototypes with properly modeled fluid dynamics can be used in designing aircraft, ships and missiles to replace wind tunnel testing: a costly and time consuming process.[1]

With this technological revolution, the present acquisition process is impractical. This chapter will provide background information on why the push for M&S; and information about some uses of models and simulations.

In the beginning it is absolutely essential to define modeling and simulation (M&S) (defined previously in Preface) as it is used throughout this guidebook (from DoDD 5000.59, *DoD Modeling and Simulation Management*).

A **model** is a physical, mathematical or otherwise logical representation of a system, entity, phenomenon or process.

Simulation is twofold: a method for implementing a model over time; and a technique for testing, analyzing, or training in which real-world systems are used, or where real-world and conceptual systems are reproduced by a model.

2.1 Today's Applications

The user community is very broad, spanning not only those involved in the employment of weapon systems, but also those involved in all phases of systems acquisition. Primary developers of today's models are war colleges, industry, DoD laboratories and universities.

There is a difference of opinion over modeling techniques; the amount of detail required; and the value of analytical models, simulations, games and field exercises. In examining these differences of opinion, there are a variety of models and each user has a different application in mind for the same model. This guide will not cover all the different opinions, nor provide an opinion on the use of one model over another. The decisions regarding the specific use of models and simulations within a given program belong to the readers. Consideration should be given to the particular activities within their programs, policies, and the guidelines and information contained within this guidebook.

The user community is divided into the following functional areas: education, training and operations; research and development; test and evaluation; analysis; and production and logistics.

Specific applications for each of the functional areas are broken out below.

- *Education, training and operations* — Re-creation of historical battles, doctrine and tactics development, command and unit training, operational planning and rehearsal, and wartime situation assessment.

- *Research and development* — Requirements definition, engineering design support and systems performance assessment.

- *Test and evaluation* — Early operational assessment, development and operational test design; and operational excursions and post-test analysis.

- *Analysis* — Campaign analysis, force structure assessment, system configuration determination, sensitivity analysis and cost analysis.

- *Production and logistics* — System producibility assessment, industrial base appraisal and logistics requirements determination.

This list is not exhaustive and not mutually exclusive, but it certainly is representative of the many applications of M&S throughout the user community.

An important aspect of the utilization of models and simulations is the application for more than one purpose. An example is the manned weapon system simulation network (SIMNET) initially developed for training, however now is being used in the development of doctrine and tactics.

2.2 Systems Acquisition Process

The goal of the systems acquisition process is to deploy, in a timely manner, and sustain an effective system that satisfies a specific user's need at an affordable cost. As stated previously, an assumption was made the

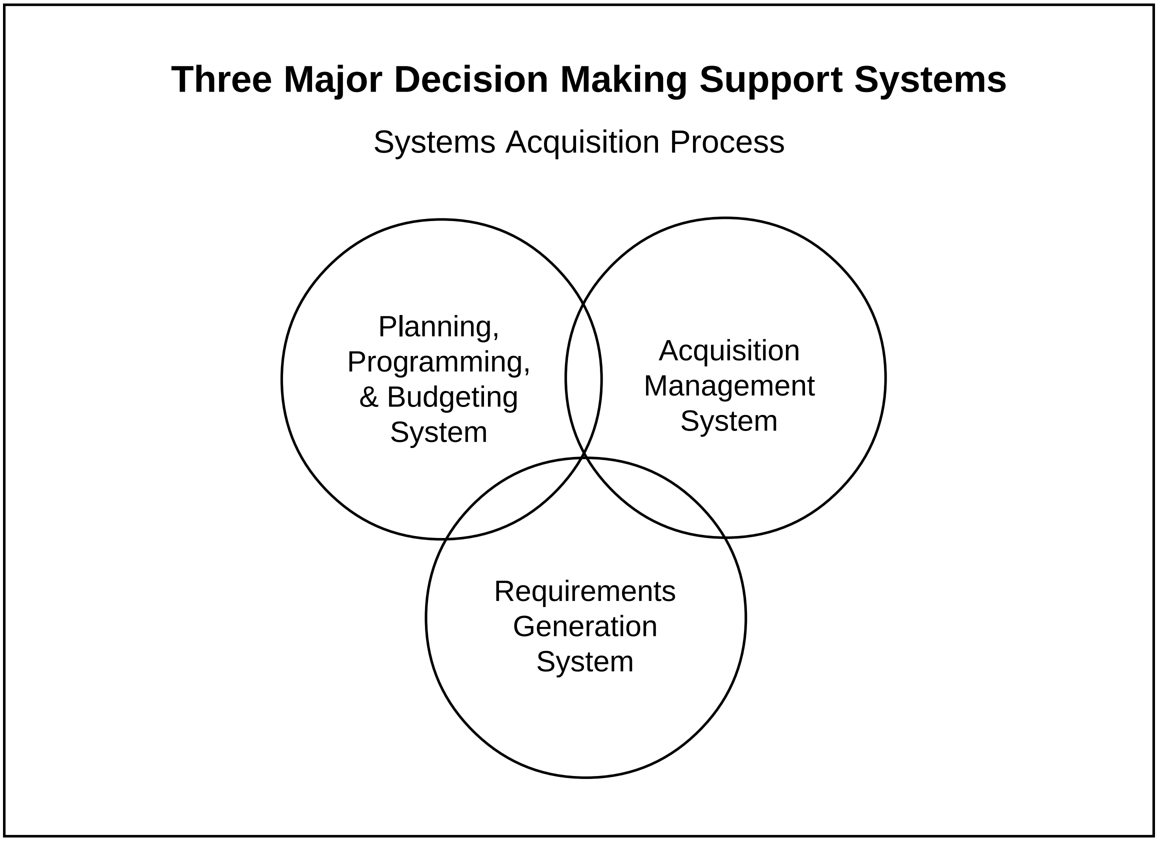


Figure 2-1. Three Major Decision Making Support Systems

reader has some understanding of the systems acquisition process as it exists today. However, the research discovered some confusion within different portions of the process.

In order to ensure the reader has a clear understanding of the systems acquisition process and information on the requirements generation system, this guidebook will briefly review those areas.

Readers that feel comfortable with the systems acquisition process may wish to skip to section 2-3 for a review of the requirements generation system—an often overlooked, but vital part of the process.

The DoDD 5000.1 establishes broad policies governing defense systems acquisition programs. It states that the three decision-making support systems must interact and interface with each other in order for the process to work effectively. The three systems illustrated in Figure 2-1[2] are: 1) requirements generation, 2) acquisition management and 3) planning, programming and budgeting system (PPBS).

The first formal interface between the requirements generation system and the acquisition management system occurs at milestone 0, supported by the Joint Requirements Oversight Council (JROC). Milestone I marks the first formal interface between the acquisition management system and the PPBS. This milestone also marks program initiation.

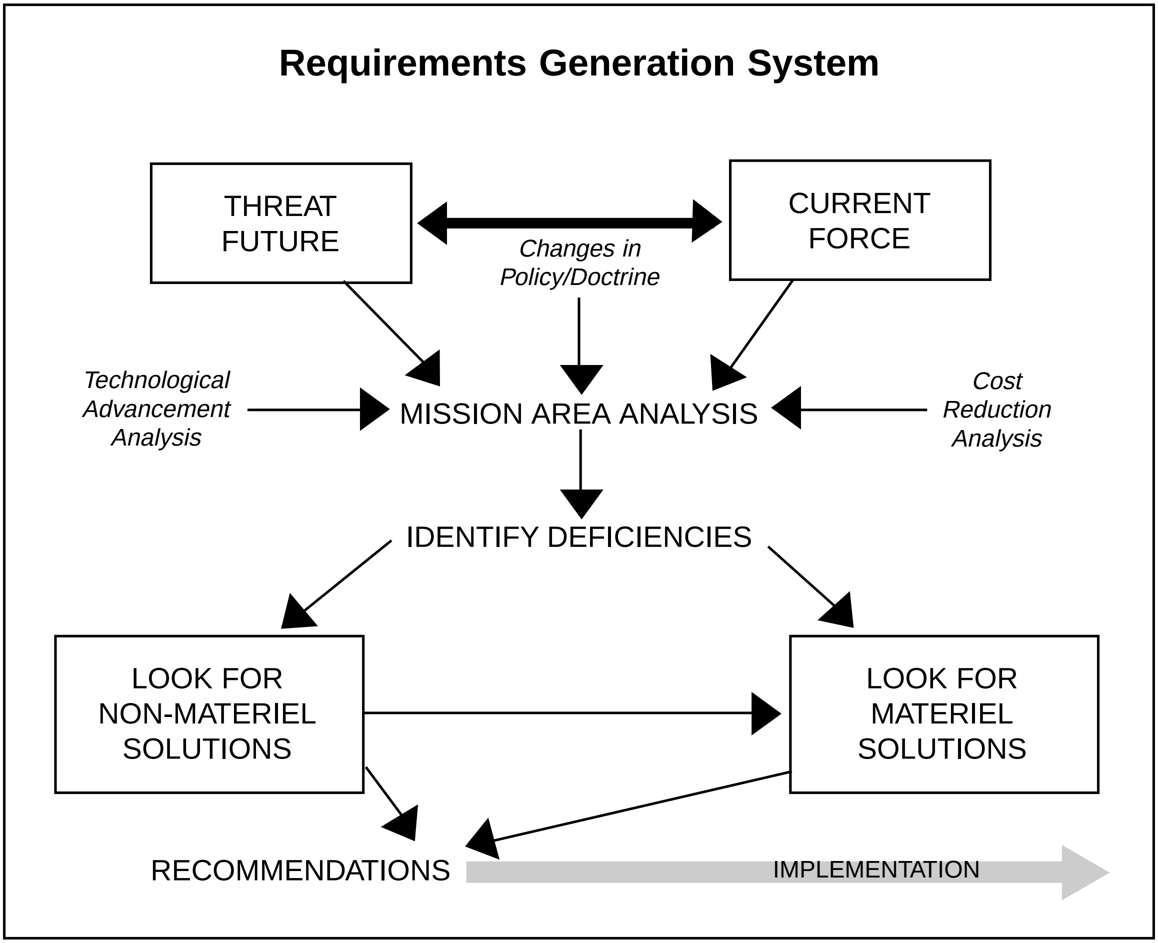


Figure 2-2. Requirements Generation System

The acquisition management system, the requirements generation system and the PPBS all interface to meet decision points at major milestone; and during each Program Objective Memorandum (POM) cycle.

2.3 Requirements Generation System

Requirements generation is based on a continuing process of assessing the capabilities of the current force structure to meet the projected threat; while taking into account opportunities for technological advancement, cost savings and changes in national policy or doctrine. Figure 2-2[3] depicts this process.

The requirements generation system consists of four distinct phases: definition, documentation, validation and approval.

2.3.1 Definition

The definition phase is an identification of a deficiency, or mismatch between current capabilities and the future (projected) threat. This process is known as a mission area assessment (MAA). Once identified, these deficiencies need to be resolved.

The first alternative is to change the organization; doctrine or tactics; or requirements for additional training. These alternatives are called non-materiel alternatives. They are investigated first because of their relatively low cost and ease of implementation. Should non-materiel alternatives prove incapable of resolving the deficiency, the next alternative is a materiel solution.

If a materiel solution is pursued, definition takes the form of translating the deficiency, or technological opportunity, into a Mission Need Statement (MNS). The MNS defines the need in broad operational capability terms, and the format is described in DoD 5000.2-M, "*Defense Acquisition Management Documentation and Report,*" February 1991, part 2.

2.3.2 Documentation

This documentation phase is the formal preparation of documents that must be coordinated with the affected authority. The MNS originator will determine whether the program is a potential major defense acquisition program (MDAP), which requires JROC action.

Materiel solutions are considered in the following order of precedence:

1) Use or modification of an existing U.S. military system.

2) Use or modification of an existing commercially developed or allied system (Non-Developmental Item (NDI) approach).

3) Cooperative research and development program with one or more Allied nations.

4) New Joint-Service program.

5) New Service-unique development program.

The MNS must be coordinated with affected Services, Commanders in Chief (CINCs), and agencies, as well as any necessary higher headquarters, before forwarding to the validation authority.

2.3.3 Validation

The validation phase is a formal review process of the documentation by an operational authority (other than the user) to confirm the identified need and operational requirement. As a minimum, the operational validation authority reviews the MNS, confirms that a non-materiel solution is not feasible, assesses the Joint Service potential, and forwards the MNS with a recommendation to the milestone decision authority (MDA) for milestone 0 action.

The Defense Intelligence Agency (DIA) will validate the potential threat to be countered and certify intelligence requirements for potential ACAT I programs.

For any C4 capability, the Director, J-6, Joint Staff, must certify the need and operational requirements for conformance to joint C4 policy and doctrine, interoperability, architectural integrity, and joint potential before approval. Validation is a necessary, but not sufficient, step for approval.

2.3.4 Approval

The approval phase is the activity to formally or officially sanction the identified need and/or operational capabilities described in the documentation. Approval also certifies that the requirements documentation has been subject to the uniform process of the DoD 5000 series and the Chairman of the Joint Chiefs of Staff (CJCS) Memorandum of Policy No. 77 (MOP 77).

Should the MNS be approved by the JROC, it will be forwarded to the Defense Acquisition Board (DAB) with the recommendation that concept direction studies be initiated. Based on a review by the DAB Committee and the DAB, the Under Secretary of Defense, Acquisition and Technology (USD(A&T)) makes the final decision as to whether or not the warfighting deficiency warrants the initiation of concept direction studies. The resulting milestone 0 decision is documented in an Acquisition Decision Memorandum (ADM), signed by the USD(A&T), the Defense Acquisition Executive (DAE) .

The MNSs for potential ACAT I level programs which are disapproved are returned to the originating service/agency.

The validation and approval authority for ACAT II, III, and IV MNSs are the service (or defense agency) chiefs or CINC of the respective Unified or Specified Command. Approved MNSs for less than ACAT I level programs are forwarded to the component acquisition executive for action.

Each Service has their own methodology for meeting the guidance provided by the CJCS MOP 77 and the DoD 5000 series documents.

ENDNOTES

1. *The Road to 2012*. (1993). Washington, DC: U. S. Department of Transportation.

2. DODD 5000.1, Part 2, Par. A.

3. Schmoll, J. H. (March 1993). *Introduction to Defense Acquisition Management*. (2nd Ed.). Ft.Belvoir, VA: DSMC Press.

3

ORGANIZATION AND POLICY

3.1 OFFICE OF THE SECRETARY OF DEFENSE ORGANIZATION AND MANAGEMENT OF MODELING AND SIMULATION

3.1.1 Background

Two offices under the Secretary of Defense (SecDef) joined efforts to improve the Department's management and technology in the areas of modeling and simulation (M&S). This led to the Deputy Secretary of Defense (DepSecDef) approving a plan to strengthen M&S applications and assigning the Under Secretary of Defense for Acquisition and Technology (USD(A&T)), the responsibility. This plan also established the Executive Council on Modeling and Simulation (EXCIMS) and the Defense Modeling and Simulation Office (DMSO).

The EXCIMS is a flag officer level advisory group to USD(A&T) on M&S policy, initiatives, standards and investments. The DMSO provides a full-time focal point for M&S activities, and promulgates USD(A&T) directed M&S policy, initiatives and guidance: promoting cooperation among DoD components.

Downward trends in the DoD acquisition budget have provided a forcing function for increased emphasis on M&S. During his testimony before the House Armed Services Committee in connection with the President's budget, March 30, 1993, the Secretary of Defense stated that DoD is planning to undertake acquisition reforms that are even bolder than the Packard Commission proposed. Goals included streamlining and improving acquisition, simplifying acquisition guidance and establishing joint civilian-military requirements. The use of models and simulations is viewed as a vital aspect of acquisition reform.

Models and simulations are powerful tools to improve the acquisition process—such as improved, up-front analysis and definition of requirements; early simulation of the development process (design, test, manufacture, support, etc.); common shared data bases; and the potential for conducting multivariate analysis in the complex "what if" world of the program manager (PM). The bottom line is M&S saves resources.

Working toward that end, the Director of

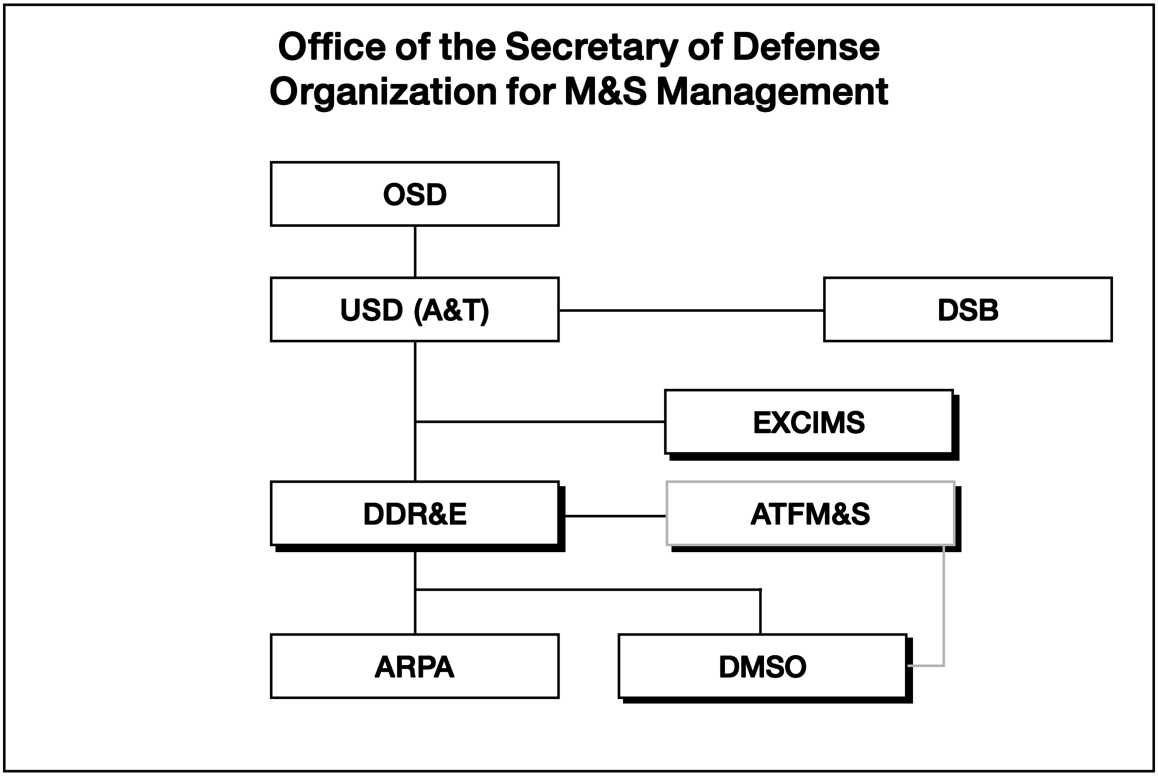


Figure 3-1. Office of the Secretary of Defense Organization for M&S Management

Defense Research and Engineering (DDR&E), established the Acquisition Task Force on Modeling and Simulation (ATFM&S), June 30, 1993, for a one year effort. The ATFM&S charter was to recommend actions that would lead to the more effective, integrated use of M&S throughout the acquisition process. Figure 3-1 illustrates the relationship among these organizations.

3.1.2 Vision for Modeling and Simulation

The stated vision of the EXCIMS reads:

Defense modeling and simulation will provide readily available, operationally valid environments for use by DoD components

- *to train jointly, develop doctrine and tactics, formulate operational plans and assess war fighting situations*
- *as well as to support technology assessment, system upgrade, prototype and full scale development and force structuring.*

Furthermore, common use of these environments will promote a closer interaction between operations and acquisition communities in carrying out their respective responsibilities. To allow maximum utility and flexibility, these modeling and simulation environments will be constructed from affordable, reusable components interoperating through an open systems architecture.[1]

More specifically, simulated warfighting environments can be constructed; allowing the Services to train the forces, plan operations and assess the status of actual operations. The training would be joint, span several echelons, involve large simulated forces, bridge large geographic regions, and involve senior commanders, as well as, units and the individual soldiers. Status monitoring would be based on electronic sand tables where disposition of friendly and enemy forces can be realistically portrayed and the consequences of those courses of action simulated.

Similarly, these environments could support the acquisition process. Simulation test beds would allow new concepts to be explored and system requirements to be refined before bending metal and committing to expensive alternate developments. Operational testing (OT) can be augmented by embedding live tests in a broader simulated environment allowing a more comprehensive systems test. Together these simulations can be used to test new systems or technologies; allowing the doctrinal and tactical implications of the new capabilities to be explored prior to any procurement or prototype development.

3.1.3 Office of the Secretary of Defense (OSD) Policy Organizations

3.1.3.1 Under Secretary of Defense, Acquisition and Technology (USD(A&T))

The USD(A&T) is the principal staff assistant and advisor to the SecDef for all matters relating to the DoD acquisition systems, research and development, production, logistics, military construction and procurement. The USD(A&T) issues plans, programs, policies and procedures for DoD M&S, in coordination with the DoD components. This office is responsible for establishing DoD-wide M&S goals and objectives and an investment strategy to achieve them.

3.1.3.2 Director, Defense Research and Engineering (DDR&E)

The DDR&E is responsible to the USD(A&T) for matters pertaining to research and engineering planning, investment, implementation and development. The DDR&E is the chair for the EXCIMS, and provides EXCIMS-developed recommendations and advice to the USD(A&T).

3.1.3.3 Assistant Secretary of Defense, Program Analysis and Evaluation ASD(PA&E):

The ASD(PA&E) is the principal staff assistant to the SecDef for DoD PA&E. The ASD(PA&E) is responsible for the critical review of requirements, performance and lifecycle costs of current and proposed weapon systems. Review of the Cost and Operational Effectiveness Analysis (COEA) falls directly under the purview of the ASD(PA&E). The ASD(PA&E) also provides leadership to the Cost Analysis Improvement Group (CAIG).

3.1.3.4 Director, Operational Test and Evaluation (DOT&E)

This office prescribes policies and procedures governing the conduct of OT&E. Provides independent assessments and reports as required by current statutes. This office also establishes policy for the application of M&S in support of OT&E.

3.1.4 Related Organizations

3.1.4.1 Executive Council on Modeling and Simulation (EXCIMS)

The EXCIMS is the advisory forum for application and control of M&S, providing recommendations to the USD(A&T) on DoD M&S goals, objectives and investment strategy. The EXCIMS oversees development of DoD M&S plans, programs, policies and procedures.

3.1.4.2 Defense Modeling and Simulation Office (DMSO)

The DMSO serves as the DoD focal point for M&S. The DMSO also serves as the Executive Secretariat for the EXCIMS and facilitates ATFM&S meetings; disseminates policy and guidance to the Services; and maintains the Defense Modeling and Simulation Information System.

3.1.4.3 Acquisition Task Force on Modeling and Simulation (ATFM&S)

A short term (one year) acquisition task force, the ATFM&S was chartered to recommend action that would lead to the more effective, integrated use of M&S throughout the acquisition process.

3.1.5 OSD Policy Documents

3.1.5.1 DoDD 5000.59, DoD Modeling and Simulation (M&S) Management (January 4, 1994)

The DoDD 5000.59 establishes DoD policy, assigns responsibilities and prescribes procedures for the management of M&S. It establishes the DoD EXCIMS and the DMSO.

3.1.5.2 Director, Operational Test and Evaluation Policy for the Application of Modeling and Simulation in Support of Operational Test and Evaluation (January 24, 1989)

This document provides policy guidance for the use of M&S in support of OT&E. It describes appropriate application of models and simulations, and guidelines to ensure credible results.

3.1.6 Additional Information

Points of contact (POCs) for M&S within OSD and DoD agencies are found in Appendix A.

3.2 JOINT STAFF ORGANIZATION AND MANAGEMENT OF MODELING AND SIMULATION

3.2.1 Background

Joint models and simulations (JM&S) are those models and simulations that represent Joint and Service forces, capabilities, materials and services used in the joint environment; or by two or more of the military Services. The JM&S support assessments, inputs to the Planning, Programming, and Budgeting System (PPBS), joint professional military education and training, realtime operational support, wargaming, and reconstruction of operations and exercises.

In the past, DoD's wargaming and assessment infrastructure were a heterogeneous mixture of systems and applications. These were independently developed, supported, and operated by the combatant commands: the Services and the Joint Staff.

The objective for the future envisions a coordinated development of JM&S to leverage both the considerable investment in existing capabilities and the competence that exists in widespread centers and users - that allow the exchange of M&S capabilities across the JM&S community. The core concept is centralized management with decentralized execution, called Distributed Models and Simulations (DMS).

Tailoring of specific JM&S capabilities from distributed M&S centers (e.g. USEUCOM

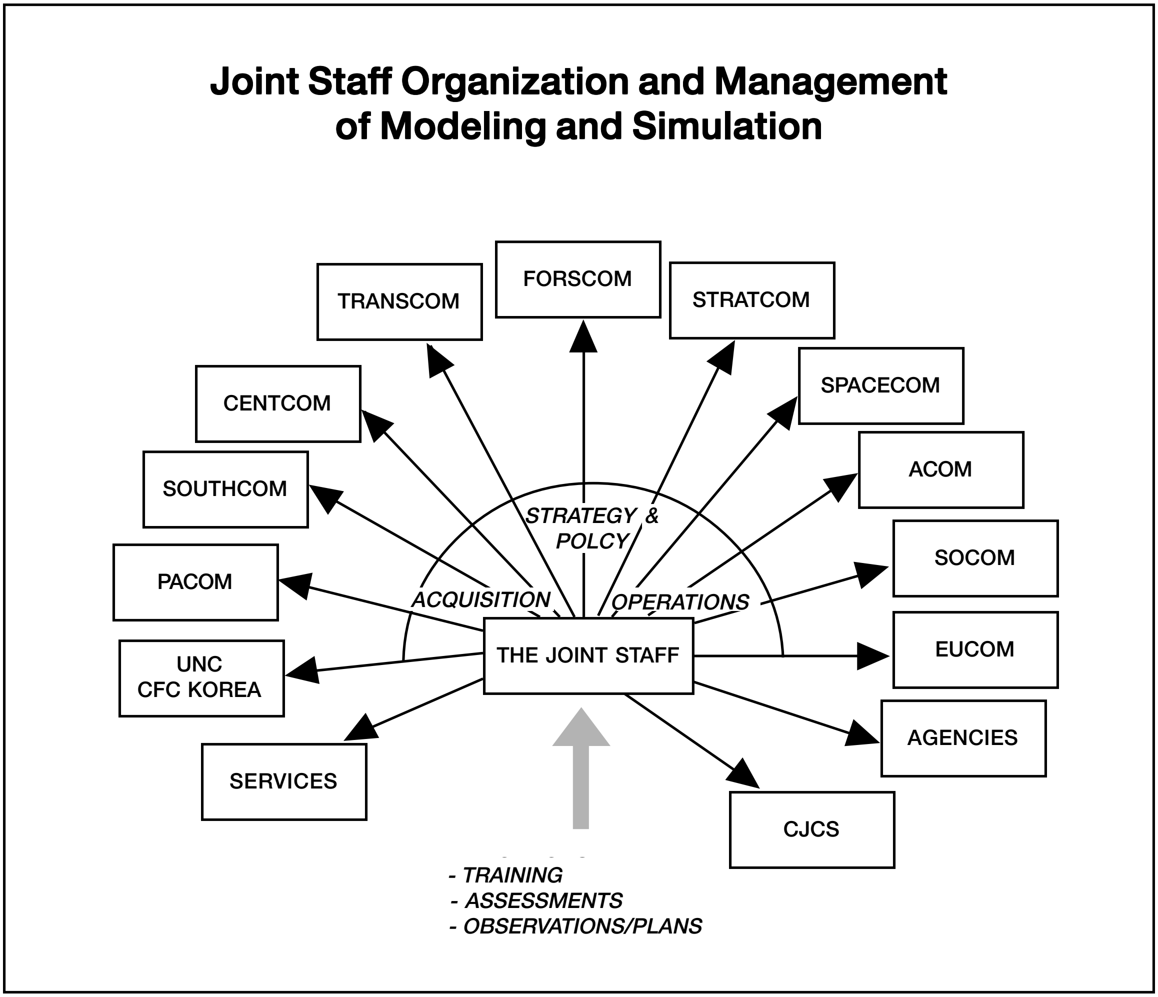


Figure 3-2. Joint Staff Organization and Management of Modeling and Simulation

Warrior Preparation Center, CFC-Korea Battle Simulation Center, Joint Warfighting Center, USPACOM Joint Task Force Simulation Center, Army National Simulation Center, Air Force Blue Flag, etc.), through fully operational distribution networks to support specific requirements for a specific user is a concept called DMS pinpoint support.

This netted pooling of expertise will (1) allow M&S to evolve as the Service/combatant command needs and capabilities evolve, (2) maximize effectiveness by allowing the Service and combatant command areas of expertise to directly affect the tools available for joint tasking and (3) maximize efficiency by enabling multiple, non-redundant, parallel operations that will help reduce the overhead of traditional stand-alone centers. This will also reduce competition for resources, assets and applications assistance.

3.2.2 Organization

Figure 3-2[2] depicts how JM&S will receive distributed support from the Services and participate in its policy development. A configuration management (CM) proponency will be established for each Service and joint-community developed JM&S. Centralized sourcing and maintenance of common data bases required for joint training and assessment will be developed and distributed via distributed networks.

The Joint Modeling and Simulation Executive Panel (JMSEP) chaired by the Deputy Director for Technical Operations, J-8, provides a forum for JM&S community interaction and cooperation.

3.2.3 Key Organizations

The Vice Director, Joint Staff, is the senior information resource management official and supervises the JM&S master planning process and approves the investment plan. All Staff Directorates play a role in developing and using JM&S within their areas of responsibility, but the key JM&S organizations on the Joint Staff are J-7 and J-8, both of which provide representatives to the DoD EXCIMS.

3.2.3.1 J-7, Operational Plans and Interoperability Directorate

The J-7 coordinates development of policy applications for the use of JM&S in support of joint doctrine development, joint training, and joint exercises. Through the Joint Warfighting Center, J-7 establishes liaison with combatant commands and Services for JM&S requirements supporting the above activities.

3.2.3.2 J-8, Force Structure, Resources and Assessment Directorate

The J-8 coordinates the development of policy applications for the use of JM&S in all areas involving analysis and analytical methodologies. The J-8 develops and maintains the JM&S master plan and JM&S investment plan, Chairs the JMSEP and formulates policy for the development, acquisition and life-cycle management of JM&S in support of joint applications.

3.2.4 Key Documents

3.2.4.1 Joint Modeling and Simulation Summary, (October 1992)

This summary presents the existing joint user results of a survey of the community as a first step in the initiative to establish and maintain the JM&S Master Planning Process.

3.2.4.2 Joint Modeling and Simulation Evolutionary Overview, (February 1994)

This document provides the JM&S community with a vision and associated policy initiatives and technical activities to support the combatant commands and Joint Staff.

3.2.5 Additional Information

Joint Staff POCs for M&S may be found in Appendix A.

3.3 DEPARTMENT OF THE ARMY ORGANIZATION AND MANAGEMENT OF MODELING AND SIMULATION

3.3.1 Background

The Army has used explicit representations of combat systems, combat and other processes for a number of years. Long before the advent of computers, the Army relied heavily upon information derived from the conduct of simulations. History contains examples of planning and rehearsing missions using sand-tables, and developing force structure and tactics using substitutes for weapons and weapon systems (such as jeeps for tanks and broom handles for rifles) during the Louisiana Maneuvers of 1940.

The sophistication of tools used to model and simulate combat systems and combat processes evolved over the years. Many major field and command post exercises were conducted using probability tables and the rolling of die to simulate the occurrence of events. Rapid advances in computer technology sped the evolution of M&S into the synthetic environment.

During the evolution from predominantly physical representations, the Army's use of M&S continued to support a variety of applications for five major purposes: education, training, and military operations; analysis; research and development (R&D); test and evaluation (T&E); and production and logistics.

The Army introduced management of its models and simulations in the early 1980s with TRADOC Regulation 5-4. Today, the Army executes management of its M&S through the Army Model and Simulation Management Office (AMSMO) with policy prescribed in Army Regulation (AR) 5-11.

Until as recently as the mid-1980s, the Army's development and use of M&S were accomplished on an as-needed and as-afforded basis. In the late 1980s, the advent of distributed simulation technology, led by the Advanced Research Projects Agency (ARPA), introduced the Army to Simulation Network (SIMNET). The SIMNET, coupled with a downward trend in defense budgets, led the Army to seek M&S applications simultaneously addressing more than one of the purposes mentioned above.

In distributed simulation technology, the Army recognized the potential for linking M&S of various types, fidelities and resolutions, and of establishing these linkages from geographically separated sites both in CONUS and overseas. In addition, the Army has been assigned the role of executive agent for DoD in developing the technology and infrastructure to support military applications of distributed interactive simulation (DIS).

The Army's model and simulation hierarchy is defined at the following levels -

1. Theater and global models and simulations, typically aggregated at brigade level and above.

2. Division/corps level models and simulations, typically aggregated at maneuver battalion level.

3. Combined arms task force, brigade level and below, high resolution models and simulations, typically representing individual weapon systems.

4. Individual item level models, which include those down to a weapon's subsystem and component level.

Army policy requires the use of *Touchstone* models and simulations (in effect, models of choice) to the maximum extent possible. Commanders are required to ensure adequate research into the ability of existing models and simulations, preferably Touchstones, to meet emerging requirements prior to initiation of an M&S development activity.

The Army has brought on line and populated the *MOdels and Simulations: Army Integrated Catalog (MOSAIC)* as a hypertext tool available to all users and developers to browse through an array of existing models and simulations. The MOSAIC offers a means to begin a search of existing M&S resources. Readers interested in more detail on *MOSAIC* are referred to Appendix B.

Beginning in 1994, the Army implemented a policy that requires all Army acquisition strategies for ACAT I and II programs (subsequently expanded to Advanced Technology Demonstrations (ATD) and Top Level Demonstrations (TLD)) to include a Simulation Support Plan (SSP). In this plan, the PM must lay out the functional requirements for M&S to support engineering and combat developments, test and evaluation, training and military exercises to support the program. The PM must also develop an M&S acquisition strategy identifying resources required to bring the M&S to fruition.

3.3.2 Organization

Figure 3-3 depicts the relationship between selected activities involved in making policy for the Army's management, development and use of models and simulations.

3.3.3 Key Organizations

This section describes the functions of those activities specifically involved in recommending, establishing or promulgating M&S policy for the Army.

3.3.3.1 Deputy Under Secretary of the Army for Operations Research (DUSA(OR))

The DUSA (OR) serves as Headquarters, Department of the Army (HQDA) proponent for Army policy on M&S, and establishes procedures and policy to support DoD M&S efforts.

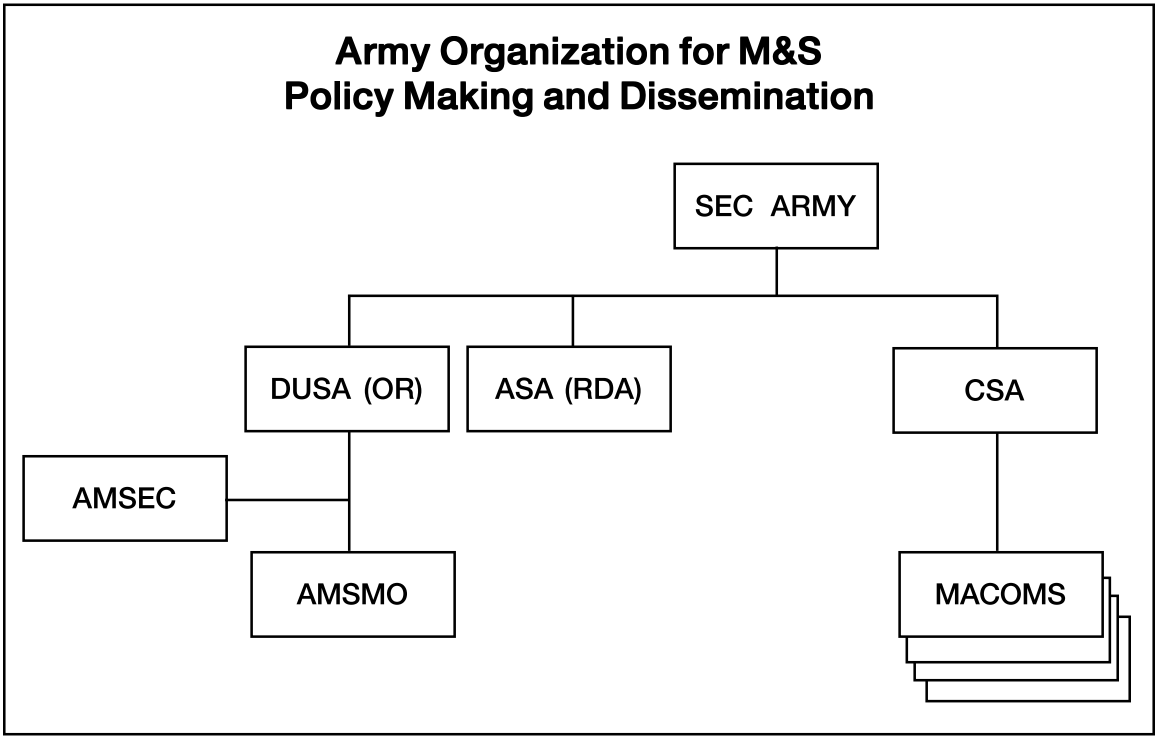


Figure 3-3. Army Organization For M&S Policy Making and Dissemination

3.3.3.2 Army Model and Simulation Executive Council (AMSEC)

The AMSEC recommends M&S policy guidance to the DUSA(OR); defines the scope of, and approves activities to be included in, the Army Model Improvement Program (AMIP) and Simulation Technology Program (SIMTECH); and nominates projects for incorporation by the DMSO.

3.3.3.3 Army Model and Simulation Management Office

The AMSMO serves as executive secretariat for the AMSEC, and executive agent for execution of the AMIP and SIMTECH programs; promulgates M&S management policy and implementing procedures, such as DA Pamphlet 5-11, *Verification, Validation and Accreditation (VV&A) of Army Models and Simulations*; develops and publishes the Army Model and Simulation Master Plan; maintains *MOSAIC*; and acts as the Army's focal point for dealing with DMSO.

3.3.4 Army Policy Related Documents

3.3.4.1 Army Regulation (AR) 5-11, *Army Model and Simulation Management Program* (AMSMP)

Policy for Army M&S management is prescribed in AR 5-11. The Army's program for management of models and simulations is formalized in AR 5-11. This regulation, and the Army Model and Simulation Master Plan take into account emerging DoD initiatives concerning management of these tools, prescribes policies and responsibilities for their management within the Army and describes organizational responsibilities.

3.3.4.2 Department of The Army Pamphlet (DA PAM) 5-11, *Verification, Validation, and Accreditation of Army Models and Simulations*

The DA PAM 5-11 provides procedures to assist model developers, proponents and sponsors to conform to the policies in AR 5-11. Specifically, it provides guidance for the development, execution and reporting of all VV&A activities. It also addresses data certification in reference to proper M&S use.

3.3.4.3 Army Model and Simulation Master Plan

This master plan provides a blueprint for investment of Army resources in an effective, efficient fashion in collaboration with other members of the DoD community. It also addresses the environment which will allow M&S technologies to advance the capabilities of a smaller, power projection Army; capable of land force dominance.

3.3.4.4 OASA(RDA) Policy memorandum, "Simulation Support to Army Acquisition," May 24, 1993

This memorandum instructs the PM to prepare a Simulation Support Plan for each ACAT I and II program going for milestone review.

3.3.4.5 DA PAM 70-XX, Army Acquisition Procedures, Part 5, Section H, "Simulation Support to Army Acquisition." (Draft)

Section H of DA PAM 70-XX provides guidance to assist in the preparation and submission of the SSP.

3.3.5 Additional Information

Readers needing more information on the M&S functions performed by the many Army commands and agencies are referred to Appendix B and the *Army Model and Simulation Master Plan*. Copies of that document can be obtained from the AMSMO.

3.4 DEPARTMENT OF THE NAVY ORGANIZATION AND MANAGEMENT OF MODELING AND SIMULATION

3.4.1 Background

Management of M&S in the Navy originally was focused on wargaming and tactical readiness. In 1992, management of M&S moved to the Assessment and Affordability Branch (N812) of the Assessments Division within the Office of the Deputy Chief of Naval Operations (Resources, Warfare Requirements and Assessments). The Naval Modeling and Simulation Program then encompassed M&S activities associated with R&D and

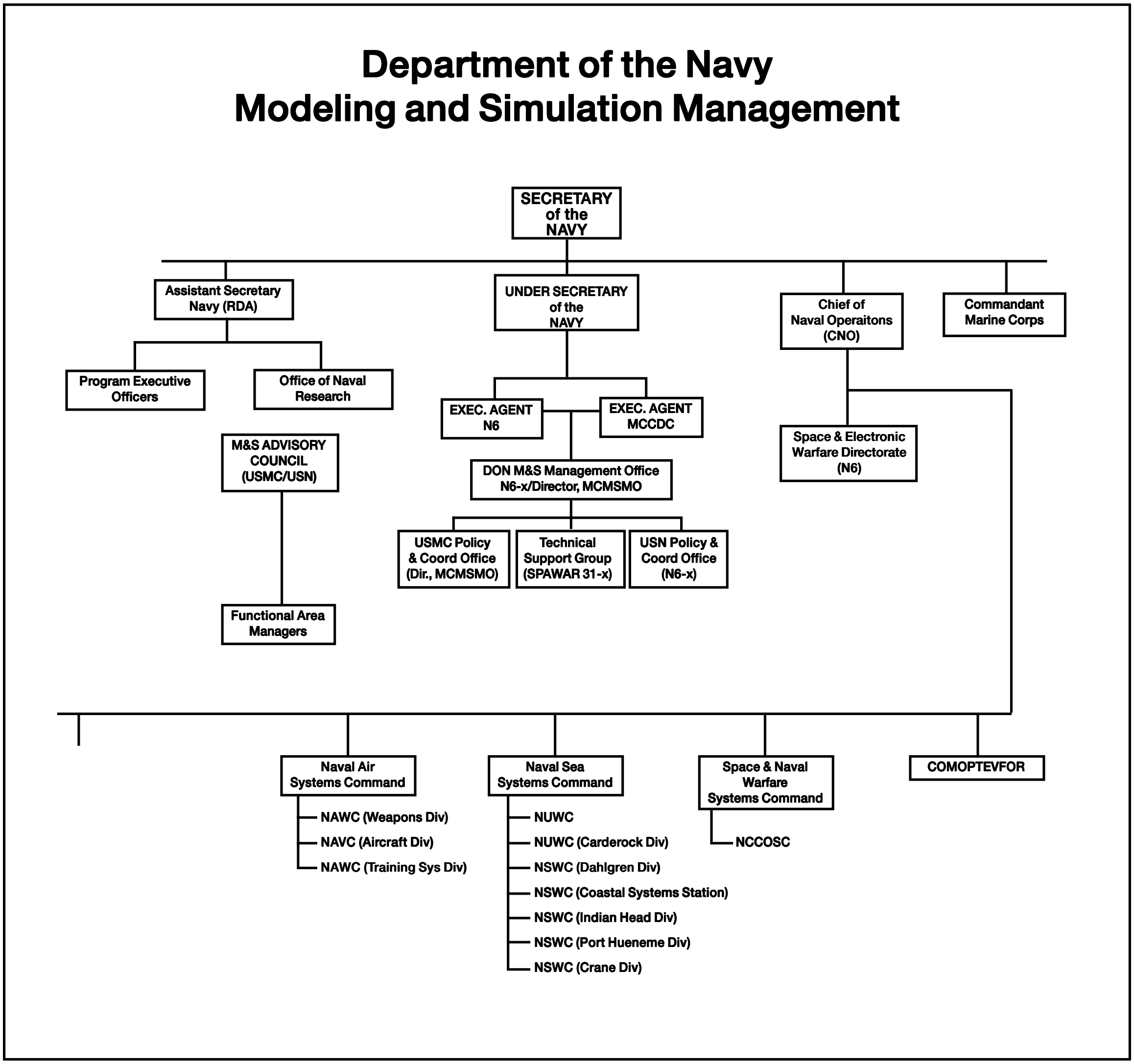


Figure 3-4. Department of the Navy Modeling and Simulation Management

T&E, education and training, production and logistics, and analysis.

Space and Naval Warfare Systems Command, (SPAWAR) provided support including maintaining a catalog for Naval Modeling and Simulation.

A Naval Warfare Analytical/Modeling and Simulation Oversight council called "Team Mike" was formed to provide guidance and coordination for the Navy's diverse modeling and simulation efforts. This organization includes representatives from the functional offices within the Office of the Chief of Naval Operations, as well as throughout the Navy support organizations, i.e., Naval Systems Commands and Naval Warfare Centers.

3.4.2 Organization

Because of the wide-ranging spectrum of M&S and breadth of the functional disciplines which M&S support; in 1994 the Navy decided to establish a management structure, shown in Figure 3-4, which addresses oversight; policy and technical support; and the users of M&S.

3.4.3 Key Organizations

The key organizations and activities included in the M&S management structure are described below.

3.4.3.1 Modeling and Simulation Advisory Council

Membership in this Council is from both the Navy and Marine Corps. This Council will:

- Advise on the formulation of the Department of the Navy (DON) M&S vision;

- Guide the development of policy, coordination and technical support; and

- Promote the use of DON-wide common support services.

3.4.3.2 Department of the Navy Modeling and Simulation Management Office

This office consists of Navy and Marine Corps Policy and Coordination offices and a Technical Support Group.

3.4.3.3 Navy and Marine Policy and Coordination Offices

Each office is responsible for:

- Writing and maintaining their respective Service Modeling and Simulation Master Plans and Investment Strategies;

- Coordinating plans, programs, policies and procedures across functional areas; and

- Maintaining instructions and standards necessary to manage M&S.

The Head of the Navy Policy and Coordination Office resides within the Space and Electronic Warfare Directorate (N6). The head of the Marine Corps Policy and Coordination Office is the Director, Marine Corps Modeling and Simulation Management Office (MCMSMO).

3.4.3.4 Technical Support Group

The Technical Support Group provides technical advice and assistance in the execution of M&S activities throughout the DON. This group's responsibilities include:

- Maintaining an automated Navy M&S Master Catalog and acting as Naval POC for input into other DoD M&S catalogs;

- Providing management of the DON

VV&A process;

- Advising in standards and protocols to be used;

- Assisting in selection and development of M&S applications;

- Building common services, tools and data bases for future development;

- Supporting development of the multi-service common simulation framework and necessary infrastructure and tools, such as common interface units, catalogs, etc.; and

- Designing distributed simulation exercises.

The Technical Support Group is led by the Space and Naval Warfare Systems Command Modeling, Simulation, and Analysis Group (SPAWAR 31) and is augmented as necessary by personnel from various Naval organizations, such as SYSCOMs, warfare centers, laboratories and federally funded research and development centers.

3.4.3.5 Executive Agents

The Director, Space and Electronic Warfare (N6) and the Commanding general, Marine Corps Combat Development Command act as Executive Agents; which participate in the Modeling and Simulation Advisory Council and jointly provide oversight to the DON Modeling and Simulation Management Office.

3.4.3.6 Functional Area Managers

Functional Area Managers are designated for the following areas: acquisition, research and development; doctrine and training systems; test and evaluation; logistics; operations; training and education; and assessment. These managers generally reside within the Chief of Naval Operations or Assistant Secretary of the Navy organizations (the exception is the Doctrine and Training Systems Manager, who is the Commander, Naval Doctrine Command). The functional area managers deal with issues across a spectrum of organizations.

- Participate as members of the M&S Advisory Council.

- Provide vision for employment of M&S to commands, facilities and organizations working within their specified functional areas.

- Promote and support participation in joint and cooperative research, development, acquisition and operation of M&S systems; technologies; and capabilities within their functional areas.

- Participate in the development of service M&S master plans, investment plans and other service planning documents.

3.4.3.7 M&S Developers and Users

M&S developers and users, such as system commands, warfare centers and laboratories, are responsible for ensuring compliance with applicable policies and procedures.

3.4.4 DON Policy Related Documents

The Navy has prepared instructions which implement the Navy M&S policies and management structure.

3.4.4.1 SECNAVINST 5200.XX: Department of the Navy Modeling and Simulation Program (Draft)

This document describes the management structure, organizational responsibilities and prescribes policy and guidance for the DON M&S program.

3.4.4.2 SECNAVINST 5200.XX; Verification, Validation & Accreditation of Models and Simulations (Draft)

This instruction establishes policy and procedures, and assigns responsibilities for M&S VV&A activities within the DON.

3.4.5 Additional Information

A list of other DON organizations, documents and a description of the Navy Modeling and Simulation Catalog are contained in Appendix C.

3.5 MARINE CORPS ORGANIZATION AND MANAGEMENT OF MODELING AND SIMULATION

3.5.1 Background

The need to carry out diversified missions, and train and equip its forces within a constrained DoD resource environment has led the Marine Corps to examine more efficient methods to define requirements; evaluate solutions; and refine system and equipment designs. Stand alone models and simulators, and advanced distributed simulation are recognized as providing the basis for improving training, acquisition decisions, test and evaluation, force structure decisions and requirements definition.

The Marine Corps has taken a series of steps to accelerate employment of M&S technologies. These include: development of a battle staff training tool, the Marine Air-Ground Task Force (MAGTF) Tactical Warfare Simulation (MTWS); development of an M&S Master Plan to provide a coherent strategy for implementing the Marine Corps simulation environment, and establishment of the Marine Corps Modeling and Simulation Office as a central focal point for M&S.

3.5.2 Organization

The management of M&S in the Marine Corps is centered in the Marine Corps Modeling and Simulation Management Office (MCMSMO) located within the Training & Education Division of the Marine Corps Combat Development Command (MCCDC). To facilitate communication, integration and decision making, the Marine Corps M&S management structure as shown in Figure 3-5 parallels the DoD M&S management structure outlined in DoD Directive 5000.59.

The Marine Corps M&S management structure consists of an Executive Steering Group, the Marine Corps Modeling and Simulation Management Office , and the Marine Corps Modeling and Simulation Working Group (MCMSWG).

3.5.3 Key Organizations

The key organizations and activities included in the M&S management structure are described below.

3.5.3.1 Executive Steering Group

A General Officer steering group designated by the Assistant Commandant of the Marine Corps (ACMC). The functions of this group include:

- Oversees the Marine Corps M&S pro-

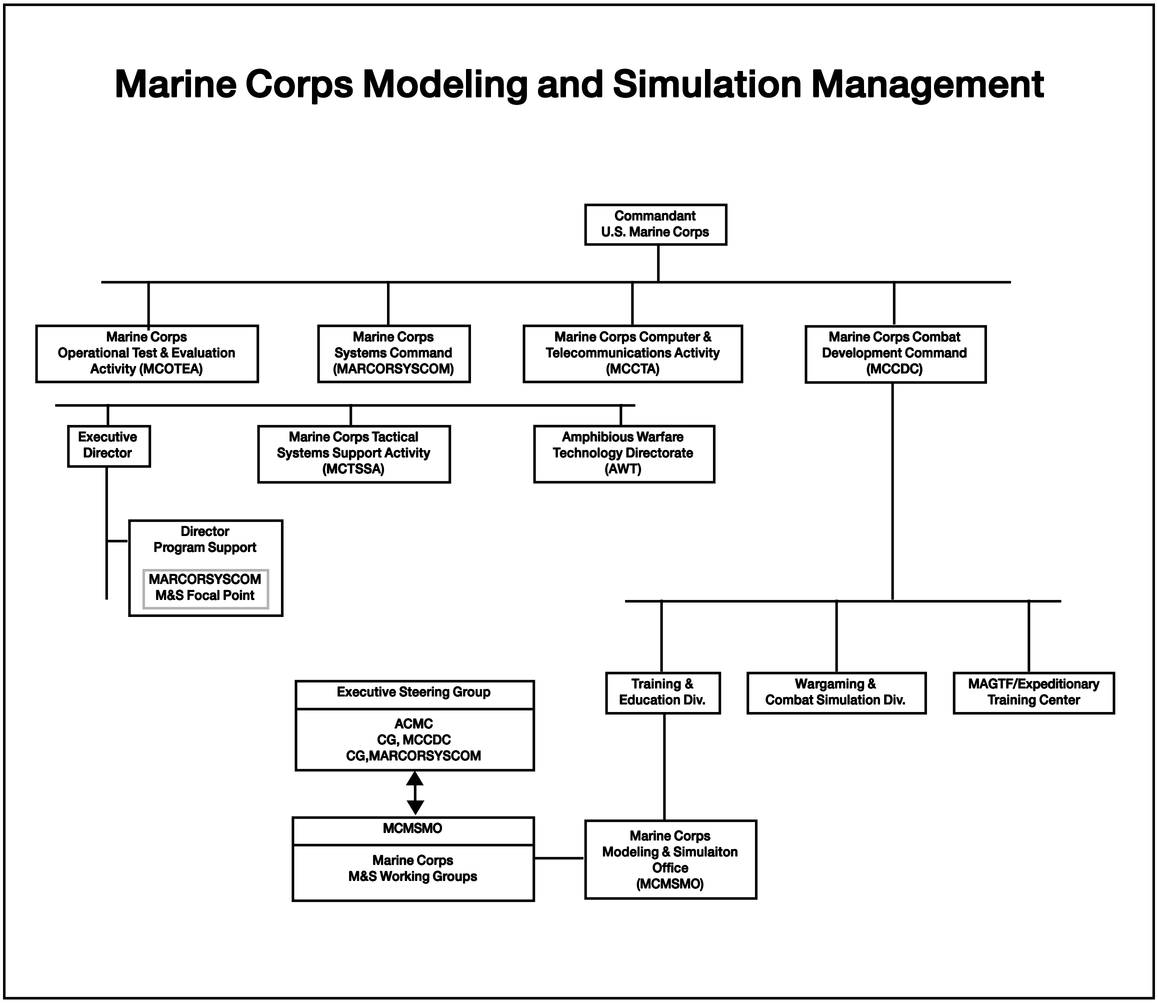


Figure 3-5. Marine Corps Modeling and Simulation Management

gram;

• Approves Modeling and Simulation Master Plan and Investment Strategy;

• Approves and provides resources for M&S initiatives as part of the POM; and

• Approves VV&A policies and procedures.

3.5.3.2 Marine Corps Modeling & Simula-tion Management Office (MCMSMO)

The MCMSMO is the Marine Corps' single focal point for M&S; providing managerial oversight of the Marine Corps M&S program, managing the Marine Corps M&S Master Plan and Investment Strategy, and supporting development of VV&A policies and procedures

The Director, MCMSMO is also the Director of the USMC Policy and Coordination

Office supporting the DON Modeling and Simulation Management Office as previously shown in Figure 3-5.

3.5.3.3 The Marine Corps Modeling & Simulation Working Group (MCMSWG).

The MCMSWG is chaired by the head of MCMSMO and performs such functions as: supports information exchange across functional areas; participates in the development of M&S policies and procedures; provides input to the M&S Master plan and Investment Strategy; recommends M&S projects for inclusion in the POM; and recommends VV&A policies and procedures.

The MCMSWG consists of representatives from functional organizations throughout the Marine Corps, and has five standing committees: VV&A, CM, functional integration, M&S Information, and data bases/scenarios.

3.5.4 Marine Corps Policy Related Documents

The Marine Corps has prepared instructions which implement the Marine Corps M&S policies and management structure.

3.5.4.1 Marine Corps Modeling and Simulation Master Plan, Marine Corps Modeling & Simulation Management Office, (Draft as of March 16, 1994)

This plan articulates the vision for the Marine Corps simulation environment; describes the technical objectives for Marine Corps constructive, virtual, and live simulations; and describes an implementation strategy including policy and management framework.

Referred to within the Marine Corps Modeling and Simulation Master Plan and its appendices, but intended to be published as separate documents are the following:

- Marine Corps Modeling and Simulation Investment Plan, (projected date May 1995)

- Procedures and Guidelines for Verification, Validation, and Accreditation

- Procedures and Guidelines for Configuration Management of Marine Corps Models and Simulators

- Marine Corps Modeling and Simulation Catalog

3.5.5 Additional Information

Other Marine Corps Organizations involved with the development, management, and/or use of M&S are listed in Appendix D.

3.6 DEPARTMENT OF THE AIR FORCE ORGANIZATION AND MANAGEMENT OF MODELING AND SIMULATION

3.6.1 Background

The Air Force has a long history of M&S applications. From the Blue Box flight simulator called *Pilot maker* to the computer aided design (CAD) and computer aided manufacturing (CAM) development of the B-2: but the road has been bumpy.

The Air Force Scientific Advisory Board (SAB) reported that the Air Force has many excellent examples of M&S; a growing need for M&S to aid Air Force decision making; demonstrated low confidence in M&S by decision makers; and a lack of coherent policy and structure.[3]

As the Services stand up to adopting more M&S applications, significant organizational changes and new initiatives are occurring.

3.6.2 Organization

The Air Force has designated the Directorate of Modeling, Simulation, and Analysis (MS&A)(HQ USAF/XOM) as the single POC for M&S issues and activities within the Air Force. They also represent the Air Force in joint, multi-service and multi-agency M&S efforts. The HQ USAF/XOM, in conjunction with all Air Force user communities, is developing formal M&S policy for the Assistant Vice Chief of Staff's (HQ USAF/CVA) approval. Figure 3-6[4] shows the Air Force's organization for M&S.

The Air Force uses MS&A at five different levels:

1. Strategic/National Military Strategy level

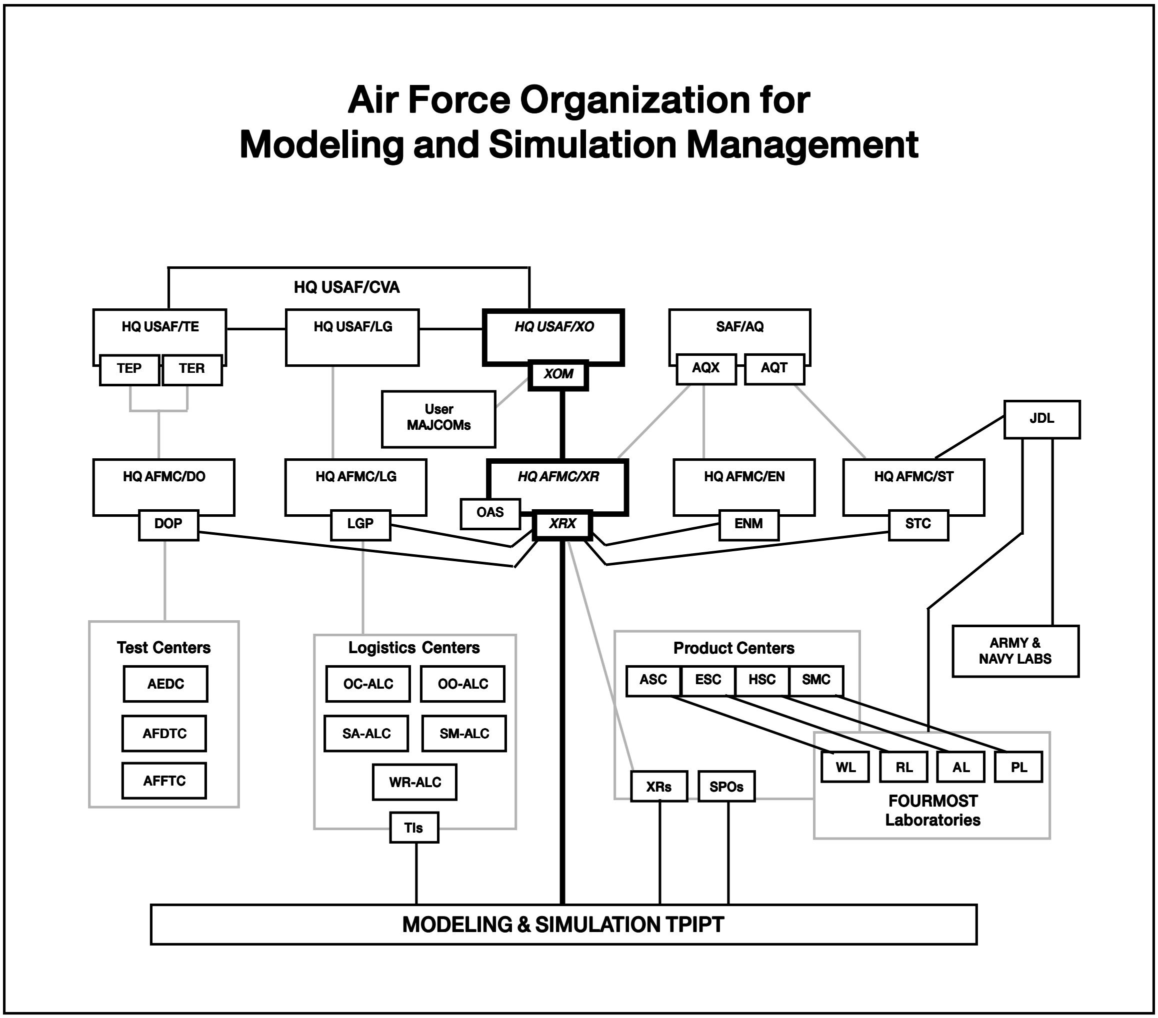


Figure 3-6. Air Force Organization for Modeling and Simulation Management

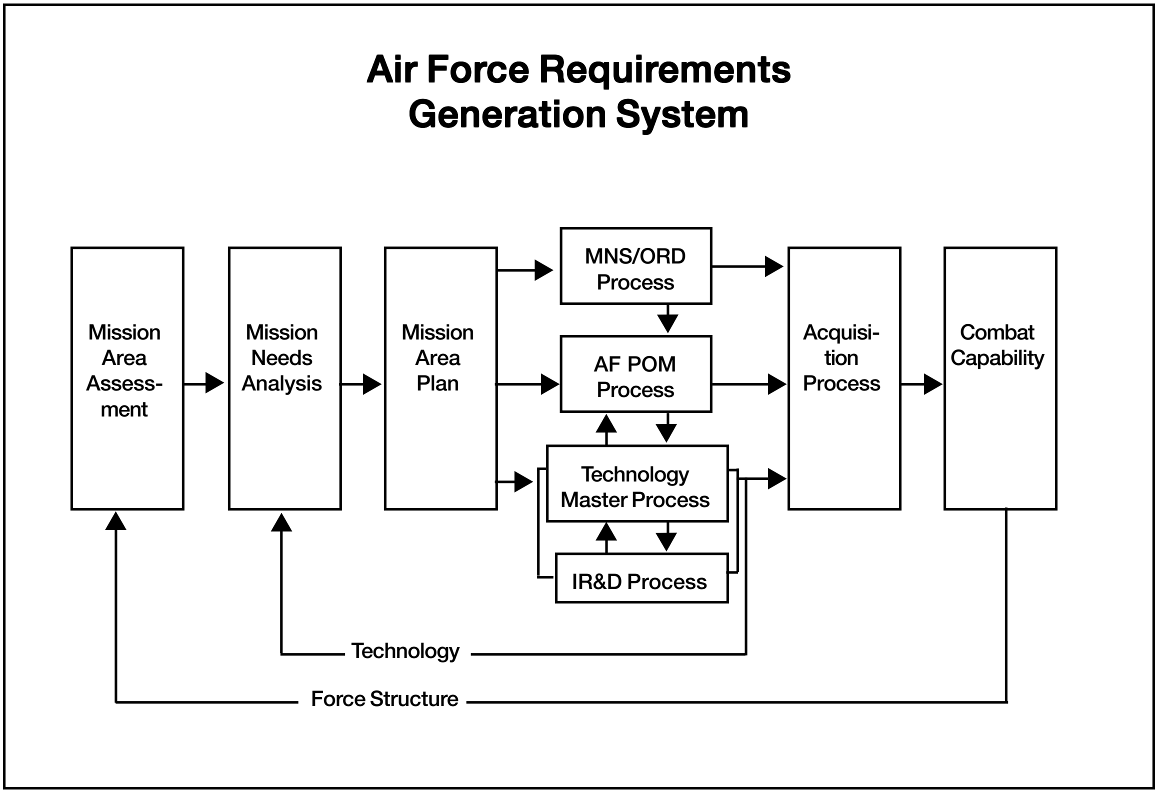


Figure 3-7. Air Force Requirements Generation System

2. Theater/Campaign level

3. Mission level

4. Engagement/Sub-mission level

5. System/subsystem component (engineering) level

3.6.2.1 Air Force Requirements Generation System

As stated earlier, each Service has their own method for meeting the Chairman of the Joint Chiefs of Staff (CJCS) Memorandum of Policy No. 77 (MOP 77) and DoD 5000 series guidance for requirements generation. The Air Force follows the same basic process as the guidance presents and adds a few management tools to assist the internal coordination for all mission area stakeholders. Refer to Figure 3-7[5].

The Mission Area Assessment (MAA) identifies the tasks to support mission objectives of a strategy-to-task analysis.

The Mission Needs Analysis (MNA) documents deficiencies in our ability to accomplish those tasks. This document never gets to the DAB. It provides the basis for the Operational Requirements Document (ORD). This document takes the task-to-need view.

The Mission Area Plan (MAP) outlines, through a series of *roadmaps*, required corrective actions. The MAPs provide the need-to-capability plans.

3.6.3 Key Organizations

The key organizations and activities included in the M&S management structure are described below.

3.6.3.1 HQ USAF/XOM: Directorate for Modeling and Simulation

This Directorate is the single POC in the Air Force for policy on modeling, simulation and analysis activity. Specifically, provides support to the Major Commands and HQ USAF in modeling, simulation and analysis that involve Air Force plans, operations and operational requirements.

3.6.3.1.1 XOME: Evaluation Support Division provides evaluation support for force structure analysis. Focus is on Studies and Analysis (S&A) policy guidance on major evaluation activities, including the COEA process and the test and evaluation process.

3.6.3.1.2 XOMT: Technical Support Division provides technology support; including policy for architecture, standards and VV&A.

3.6.3.1.3 XOMW: Warfighting Support Division provides S&A policy guidance for education and training of Commanders and Battle Staffs; real-time and interactive.

3.6.3.1.4 AFSAA: Air Force Studies and Analysis. The recent reorganization of HQ USAF/XO incorporated Air Force S&A under XOM as a Field Operating Agency. They provide force application support with campaign analysis, theater air defense information, weapons and tactics information, and force employment analysis; force enhancement information and analysis for global deterrence, global mobility, space and C3I, and force support; and support for wargaming exercises.

3.6.3.2 HQ AFMC/XRX: Director for Opera-tional Requirements

Provides M&S direction/policy for AFMC acquisition M&S. This office is the single AFMC POC for acquisition M&S correspondence with the HQ USAF and SAF offices and AFMC centers/field units.

3.6.3.3 Technical Planning Integrated Product Team (TPIPT)

The ESC/XRP chairs this team that is comprised of members from all AFMC product centers. The M&S TPIPT integrates and coordinates AFMC M&S activities, provides responses to higher headquarters and plans for M&S tools that will support acquisition; while being accessible and beneficial to wargaming and training.

3.6.4 Air Force Policy Related Documents

3.6.4.1 AFPD 16-10, Modeling and Simulation (M&S) Management, (Draft, May 1994)

This directive provides general policy for M&S throughout the Air Force and assigns responsibilities. It also implements DoDD 5000.59, *DoD Modeling and Simulation Management*.

3.6.4.2 AFI 16-1001, Verification, Validation and Accreditation, (Draft)

Provides specific responsibilities, procedures, formats and guidelines for VV&A.

3.6.4.3 AFI 16-1002, M&S Management, (Draft)

Provides specific responsibilities, procedures, formats and guidelines on the management of M&S.

3.6.4.4 AFMCP 800-66, Air Force Materiel Command Models and Simulations Guide, (July 1993)

This document provides guidance for M&S applications through the life cycle of Air Force weapon systems. The guide focuses on the systems engineering approach and is designed to support the Integrated Weapon System Management (IWSM) concept. The scope is a general overview of M&S applications, not detailed descriptions.

3.6.4.5 AFPD 10-6, Mission Needs and Operational Requirements, (January 1993)

This policy directive establishes general policy, assigns oversight responsibility, implements DoD 5000 series documents into the Air Force and identifies AFI 10-601 as a companion to this policy directive.

3.6.4.6 AFI 10-601, Mission Needs and Operational Requirements Guidance and Procedures, (1994)

The AF 10-601 provides guidance in preparing, validating and approving Mission Need Statements (MNS), ORDs (including the Requirements Correlation Matrix (RCM)), and COEA.

3.6.4.7 AFPD 10-14, Air Force Policy Directive on Modernization Planning, (Draft)

This policy directive establishes the modernization planing process to identify and correct deficiencies in mission and functional areas.

3.6.4.8 AFI 10-1401, Modernization Planning Documentation, (Draft)

This instruction establishes responsibilities and defines major processes for development of MAPs used in the modernization planning process.

3.6.5 Additional Information

Additional information on relative documentation, key organizations and points of contact are contained in Appendix E.

ENDNOTES

1. Executive Council on Modeling and Simulation. (May 1992). Vision as stated in the Defense Modeling and Simulation Initiative. Washington, DC: Department of Defense.

2. Joint Modeling and Simulation Evolutionary Overview, The Joint Staff (J8/RPPD). February 1994.

3. Air Force Sscientific Advisory Board ad-hoc committee on Modeling and Simulation, December 1991; and 1993 Summer Study for TMD.

4. HQ Air Force Materiel Command, Development Planning Division, Deputy Chief of Staff for Requirements (HQAFMC/XRX), Wright-Patterson AFB, OH.

5. HQ Air Combat Command, Requirements Management Division (ACC/DRM), Langley AFB,VA.

4

CLASSIFICATION OF MODELS AND SIMULATIONS

There were over 500 Models and Simulations (predominantly computer models) listed in the Twelfth Edition of the Joint Chiefs of Staff (J-8) Models and Simulations Catalog[1] alone. Many more models and simulations are listed in other catalogs throughout DoD or used in support of specific programs without being included in any catalogs or formal listings.

The intent of this guidebook is to describe the forms that models and simulations take and their uses in acquisition; rather than serve as an additional catalog.[2]

The discussion of the types of models and simulations will begin by laying out a framework of model and simulation classes. This is to show the breadth that models and simulations encompass and to provide the acquisition community with an understanding of terminology.

Before proceeding further, the reader is cautioned not to become too enamored with the terminology, nor should one try to fit every model or simulation neatly into one of the classes. In the authors' opinion, the lines among the various classes of models and simulations are becoming blurred —technology allows linkage and interoperability among the various classes of models and simulations, and human interactions can span across all the classes. Therefore, one often is not simply talking about a single model or simulation, but rather hybrids formed from among two or more classes.

The Defense Science Board in 1992 defined an appropriate classification of models and simulations similar to that depicted in Figure 4-1.[3] These classifications find useful application to the systems acquisition process and have been elaborated upon in more recent publications as follows:

"Constructive. Wargames, models and analytic tools …

Virtual. Systems simulated both physically and by computer. Real people fight [and train] on synthetic battlefields, interacting with each other and with artifacts in the simulation. Examples include individual aircraft [weapon system] simulators and virtual prototypes.

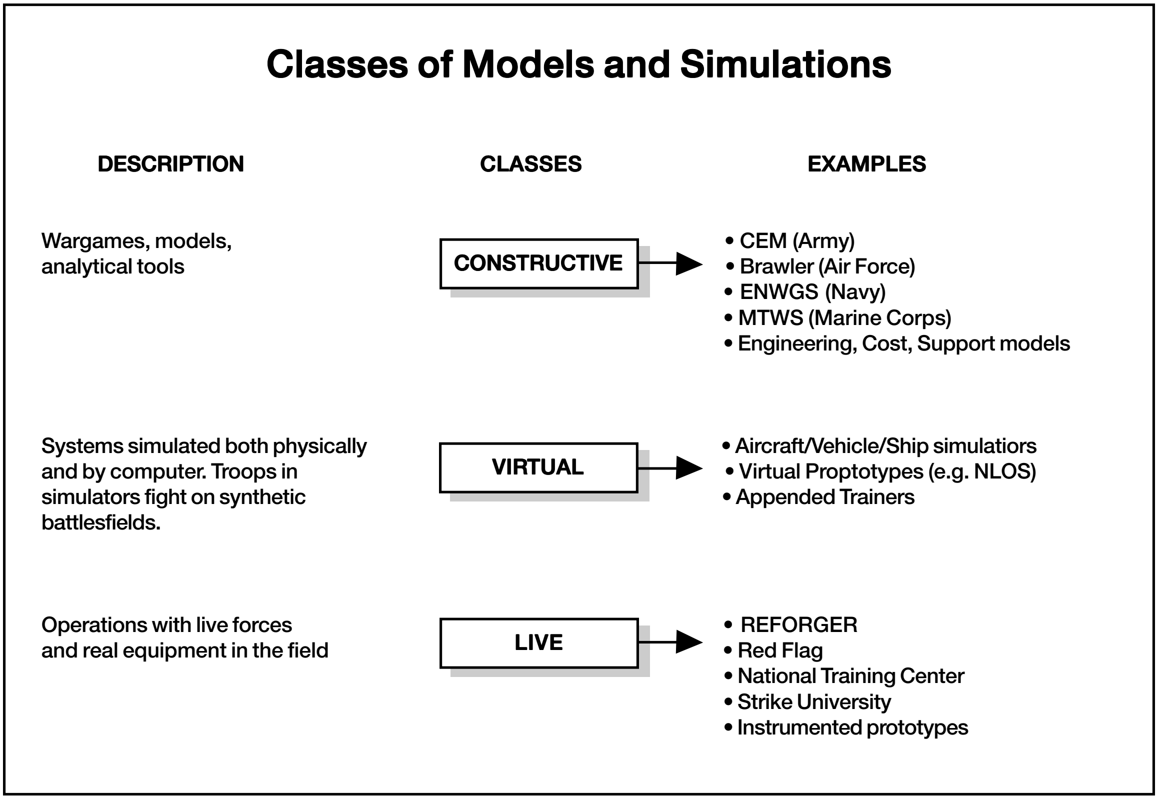


Figure 4-1. Classes of Models and Simulations

Live. Operations with live forces and real equipment in the air, on the ground, on and below the sea. Also included are hardware prototypes on instrumented ranges."[4]

This Chapter will concentrate on further describing these three classes of models and simulations; introducing the reader to what is termed *hierarchies* of models and simulations, and providing a discussion of hybrid applications. Chapter 5 will then describe the application of modeling and simulation (M&S) across the acquisition life cycle, as well as to various acquisition activities.

4.1 Constructive Models and Simulations

The models and simulations contained within this class currently represent the predominant form of M&S tools used within or in support of a program office.

Constructive models and simulations consist of computer models, wargames and analytical tools which are used across a range of activities. At the lowest levels, they may be used for detailed engineering design and costing, or subsystem and system performance calculations to support development of technical specifications. Higher level models and simulations provide information on the outcomes of battles or major campaigns involving joint or combined forces, identify mission needs and support operational effectiveness analyses.

A variety of constructive models may be used to represent a system and its employment at different levels of detail, from engineering physics of piece parts to aggregated combat forces in a campaign analysis.

Many constructive simulations may be performed either with or without human interaction. Without human interaction, they might be run in multiple iterations to provide statistical confidence in the outcomes of the simulation. With human interaction, they are often referred to as wargaming simulations and are used for battle staff training or tactics development. The tactics developed in such interactive simulations may then be used for establishing tactics within the non-interactive simulations.

Within acquisition, the uses of constructive models and simulations include design and engineering trade-offs, cost, supportability, operational and technical requirements definition and operational effectiveness assessments.

4.2 Virtual Simulation

4.2.1 Human-in-the-Loop

Virtual simulation brings the system (or subsystem) and its operator together in a *synthetic*, or simulated environment. Although this document uses the term human-in-the-loop to represent these simulations, other names include man-in-the-loop, warfighter-in-the-loop, or person-in-the-loop.

In a virtual simulation, the system may include actual hardware which is driven (stimulated) by the outputs of computer simulations. As an example, a weapon system simulator may employ a near-real crew compartment with the correct equipment, controls and display panels. A computer generated synthetic environment is then displayed on a screen in front of the crew and reflected in the crew compartment instrumentation and displays. Motion of the platform may be driven by the computer simulation to represent the system dynamics. Sounds of the system and equipment can also be duplicated. The operators are thereby immersed in an environment driven by the simulator that to them *looks, feels, and behaves* like the real thing. During simulated missions, the crew must operate the equipment, receive commands and control weapons just as in a real system.

Human-in-the-loop simulations provide a better understanding of human reactions and decision processes and man-machine interfaces. They can provide a platform for crew training prior to live exercises and tests, or realistic mission rehearsal in preparation for actual combat operations.

Linked to other simulators, the interaction of multiple weapon systems can be examined, leading to changes in tactics or engagement rules. These simulations also provide powerful tools for evaluation of actual system hardware and software within realistic environments for developmental programs.

Human-in-the-loop simulations run in real time, and hence fewer iterations may be performed than with non-interactive constructive simulations.

4.2.2 Virtual Prototypes

A more advanced concept for virtual simulation is on our doorstep—virtual proto-typing. In this realm, a three-dimensional electronic, *virtual mockup*, of a system or subsystem allows an individual to interface with a realistic computer simulation within a synthetic environment.

The representation is solely a computer

simulation rather than actual hardware and may be applied in early prototyping work to evaluate concepts; human-machine-interfaces; or to allow designers, logistics engineers and manufacturing engineers to interface with the same design. Such an approach supports Integrated Product and Process Development (IPPD) or concurrent engineering, by providing a common platform from which all functional disciplines can work.

This concept of the designer, operator, maintainer and manufacturer all interacting with the same realistic three-dimensional representation of the system will become more prevalent in future acquisition. For a detailed description of the capabilities of virtual prototyping, the reader should examine reference 4 at the end of this chapter.

4.3 Live Simulations

"Everything is simulation except combat."[5] Live exercises where troops use equipment under actual environmental conditions approaches real life in combat. The live simulation provides a testing ground to provide live data on actual hardware and software performance in an operational environment.

These data also can be used to validate the models and simulations used in an acquisition program. This form of simulation provides the stress and decision-making that is associated with human-in-the-loop simulation. The introduction of multiple types of platforms allows for evaluation of actual interaction and interoperability. However, assembling the personnel and equipment and conducting a live simulation is a resource intensive enterprise requiring time, funds and people.

Constructive and virtual simulations may already have been conducted prior to live simulations to plan the tests or exercises, identify critical issues, rehearse the mission or train the participants. They may also be used to analyze results after the test, or augment tests to address scenarios that may not be feasible due to safety or environmental reasons. With the high cost of live simulations (tests), the use of other, less resource intensive forms of M&S is a smart preparation tool. For example, an air-to-air missile in development might be valued at $1M, and a training torpedo firing could cost up to $50K. As an integral part of test planning and support, M&S will allow a program manager (PM) to use such valuable assets more efficiently. For even greater benefits to their programs, managers must insure that live simulations include adequate instrumentation. The data thereby collected will serve two important purposes: further validation of models and simulations; and providing "ground truth" data to support post-exercise debriefs.

As the reader has seen within the previous discussion, human interaction may be a part of any of the classes of M&S. The acquisition program manager may choose to employ human interaction in M&S to satisfy two functions:

- Determination of human decision making or logic patterns and their impact on system performance and effectiveness. Simulations of any class requiring human input may serve this function.

- Identification and refinement of human-machine interfaces. This results from simulations which allow for the human to act as part of the system, such as in manned simulators or live exercises.

These three classes of models and simula-

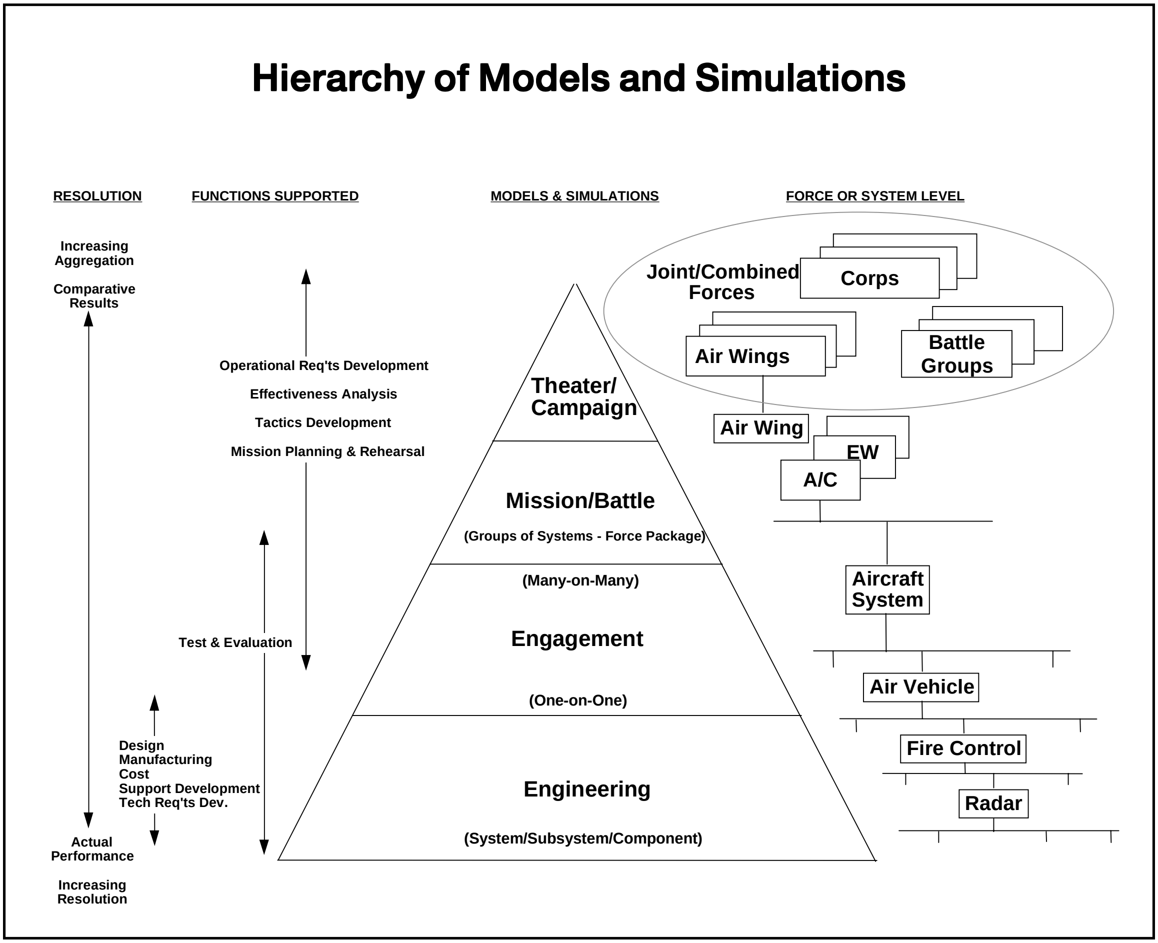


Figure 4-2. Hierarchy of Models and Simulations

tions (constructive, virtual and live) may be found in varying levels of detail to support activities ranging from detailed engineering design to the military utility of a new system or technology on the battlefield. To describe the different levels of models and simulations used to support these activities, a hierarchy of models and simulations is introduced.

4.4 Hierarchy of Models and Simulations

Models and simulations support acquisition program activities ranging from design to operational effectiveness assessments. This assortment of tasks requires a suite of models and simulations with differing levels of detail suited to their particular application. These models and simulations form what may be called a hierarchy of models and simulations.

Hierarchies of models and simulations are described in documented form[6] and also found in undocumented form throughout the DoD.

The authors have found that these hierarchies are similar in concept and vary only in detail. Some extend to higher levels, including national policy and force structure planning, while others extend down to include actual testing. This document describes a hierarchy that is representative of those that the reader may come across or use. This hierarchy is depicted in Figure 4-2, alongside a force level and system work breakdown structure (WBS) to indicate the system level that corresponds with the level of analysis to be performed.

The levels within this hierarchy include:

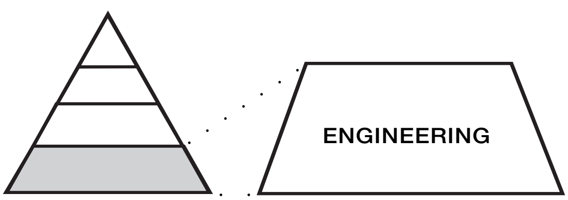
- **Engineering**: for design, cost, manufacturing and supportability. Provides measures of performance (MOP).

- **Engagement**: for evaluating system effectiveness against enemy systems. Provides measures of effectiveness (MOE) at the system-on-system level.

- **Mission/Battle**: effectiveness of a force package, or multiple platforms performing a specific mission. Provides MOE at the force-on-force level.

- **Theater/Campaign**: outcomes of joint/combined forces in a theater/campaign level conflict. Provides measures of value added at the highest levels of conflict, sometimes called measures of outcome (MOO).

4.4.1 Engineering Level Models and Simulations



Engineering level models and simulations are concerned with the performance; producibility; supportability; cost of components, subsystems and systems; and the trade-offs associated therewith. At the engineering level there are literally thousands of models and simulations including:

- Basic phenomenology such as aerodynamics, fluid flow, hydrodynamics, heat transfer, acoustics, fatigue, etc.

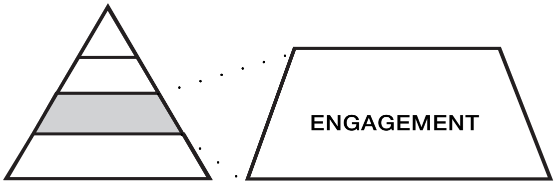
- Physics based models of components; subsystems; and systems for design, performance, costing, manufacturing and supportability.

For acquisition, engineering level models and simulations provide the basis for design trade-offs at the component, subsystem and system levels; support development of technical design specifications; and support test and evaluation. Cost models provide development, production, and operations and support costs. Support models can include reliability, availability and maintainability; level of repair; and provisioning analyses. Manufacturing models and simulations can provide information on producibility of a particular design, as well as, simulation of work flow on the factory floor and identify facilitization requirements.

These engineering level models indicate performance capabilities, often termed MOP. Examples of these measures include radar acquisition range, miss distance, range, payload or speed. Such performance parameters might be used in the system and development specifications.

The representations of the system in higher level models and simulations should have their basis in these engineering level models. It is in those higher level models and simulations that the actual impacts of weapon system performance on combat effectiveness is evaluated.

4.4.2 Engagement Level Models and Simulations

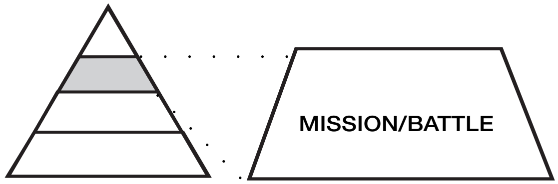


Engagement models and simulations represent the system in a limited scenario, such as one-on-one, few-on-few or sometimes many-on-many. This level of simulation evaluates the effectiveness of an individual platform and its weapons systems against a specific target or enemy threat system. These models rely on system performance, kinematics and sensor performance from the engineering level models and simulations. They provide, survivability, vulnerability and lethality results for measures of system effectiveness or for use in higher level models. Detailed performance of the subsystems such as propulsion, combat systems, sensors, and guidance and control may be included and evaluated.

The outputs of engagement level models and simulations indicate the effectiveness of systems and subsystems in an engagement scenario and are termed MOE. Examples include probability of kill, losses or mission aborts.

Acquisition uses of engagement level models and simulations include identifying system effectiveness and performance to support requirements documents (mission need statement (MNS) and operational requirements document (ORD)) and Cost and Operational Effectiveness Analyses (COEA), system level performance trade-offs, test and evaluation support, and evaluation of tactics changes and new weapon concepts.

4.4.3 Mission/Battle Level Models and Simulations



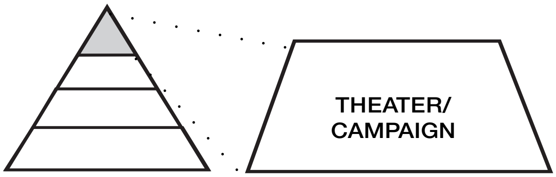
Mission/battle level models and simulations reflect the ability of a multi-platform force package to accomplish a specific mission objective, such as air superiority, interdiction or strike which might span a period of hours. It might consist of an attacking force of fighter and electronic warfare aircraft; a combined arms group attack or defense; or carrier battle group operations consisting of aircraft, ships and combat systems against an integrated air defense (e.g., Surface-to-Air Missiles, enemy air assets).

In conjunction with human participation, mission/battle level simulations may be used for wargaming, training and tactics development.

The outputs of mission/battle level models and simulations are MOE. Typically at a force package level rather than at the level of the individual platform and its weapon system. Examples of these MOEs might include loss exchange ratios, probabilities of engagement or success in achieving a specific mission objective.

The acquisition applications of such M&S include analysis in support of requirements for the MNS or ORD; operational effectiveness analyses for alternatives evaluation in COEAs; examination of interoperability and compatibility issues; and in support of test and evaluation.

4.4.4 Theater/Campaign Models and Simulations



Theater/campaign models and simulations represent combined force combat operations and are used to determine the long term outcome of a major theater or campaign level conflict. Forces are often represented as aggregations of lower level forces and systems. These models and simulations can identify major deficiencies in capabilities of force structures and employment alternatives.

Since these simulations usually encompass longer periods of warfare they are more likely to include sustainment representations within the model. These models usually require the results of lower level (engineering, engagement or mission/battle) models and simulations as inputs to generate the aggregated-force level capabilities. Some may even have the capability to directly incorporate more detailed models of specific systems within their input architectures.

As with models and simulations within other levels of the hierarchy, theater/campaign level simulations might be run with human interaction. In this interactive mode, they may by used as a wargaming tool for battle staff training or tactics development.

Whereas the engineering level models are used to determine actual performance values for the components, subsystems, or systems being modeled; the higher level models in the hierarchy are used to establish trends, identify driving factors and obtain relative comparisons of military utility among systems or groups of systems being analyzed.

The measures which result from theater/campaign level models and simulations are sometimes termed outcomes. Examples may include force drawdowns or battle group losses, air superiority and ground force movements.

Acquisition applications of theater/campaign level models and simulations include evaluation of force level combat outcomes in conducting Mission Area Assessments (MAA) leading to development of MNS; support of COEAs; and evaluation of the impacts of new systems or operational concepts.

The hierarchy discussed above represents an integrated framework for analysis of performance, effectiveness, tactics and doctrine, and conflict outcomes. Each level in this integrated framework is aimed at addressing specific issues and relies on information obtained in analyses conducted at other levels. Figure 4-3 summarizes the primary attributes of the various models and simulations within each level of the hierarchy along with representative examples.

4.5 Hybrid Models and Simulations

Up to this point, the classes (constructive, virtual and live) and a hierarchy of models and simulations have been described. In many applications, linkage among two or more classes is actually used resulting in hybrid models and simulations. Such a hybrid might employ constructive analytical models to represent a threat or the kinematics of a weapon in conjunction with actual (live) system hardware and software. Examples of such hybrid applications include physical simulations, stimulators, hardware/

Attributes and Uses of Models amd Simulations within the Hierarchy

LEVEL OF MODEL	Engineering	Engagement	Mission/Battle	Theater/Campaign
FORCE	Single Weapon Systems, Subsystems, Components	One to a Few Friendly Entities Vs. one to a few Enemy Entities Engagement	Multi-Platform, Multi Tasking Force Package	Joint/Combined
LEVEL OF DETAIL	Highly detailed - down to individual piece parts, their interaction & phenomenology	Individual entities Detailed subsystems	Some Aggregation or Individual Entities	Highly Aggregated Down to Individual Entities (Tank, Ship, A/C)
TIME SPAN	Months - Sub-Seconds	Minutes-Seconds	Hours-Minutes	Weeks-Days
OUTPUTS	• Measures of <u>*Performance*</u> of System, Subsystems, & Components (e.g. Miss Distance, target acquisition range) • Cost, Supportability, Producibility	• System <u>*Effectiveness*</u> (e.g. Probability of Kill, Losses, Aborts, Survivability, Vulnerability)	• Mission <u>*Effectiveness*</u> (e.g. Loss exchange ratios, probabilities of Engagement)	• Campaign <u>*Outcome*</u> (e.g Air Superiority, Force Drawdowns, Ground Force Movements)
USE	• Design • Subsystem & Component Performance & Tradeoffs • Specification Reqtuirements & Compliance • Cost, Support, Producibility • Test Support • Facilitate IPPD	• Alternative Eval (COEA) • Requirements (MNS, ORD) • System Effectiveness • System Tradeoffs • Tactics, rules of Engagement • Test Support	• Alternative Eval (COEA) • Requirements (MNS, ORD) • Deployment • Weapons Integration • Interoperability • Tactics & Ops Concepts • Training & Wargaming	• Alternative Eval (COEA) • Requirements (MNS, ORD) • Tactcs/Employment • Wargaming • Battle Staff Training • Sustainment Issues
EXAMPLES (Typical Uses)	Many, throughout R&D Centers, Labs, Contractors, such as: 6-DOF CAD/CAM HW/SWIL Cost Factory simulation Support (LORA, RAM)	Eagle, Janus SSTORM Brawler,ESAMS	Janus, Eagle WEPTAC, SIM II Suppressor,EADSIM	Campaign Exercise Model ENWGS, CAAM AWSIM, Thunder MTWS

Figure 4-3. Attributes and Uses of Models and Simulations within the Hierarchy

software-in-the-loop (HW/SWIL) simulations and advanced distributed simulations (ADS).

4.5.1 Physical Simulation

Much of the discussion within this Chapter has focused on electronic representations of systems and subsystems. Physical simulations may refer to a physical representation of the actual operating environment (e.g. temperature, humidity, shock, vibration, etc.) or physical models used in simulating the operation of a system or subsystem. Examples of physical simulation include:

- Munitions shock and vibration testing using a simulated environment;

- Survivability/ vulnerability evaluations using prototype structures and environmental conditions, such as high speed airflow over the structure, simulating flight conditions;

- A firing impulse simulator (a hydraulically operated ram) used to provide an impulse to the gun barrel to physically replicate the shock of a round being fired for durability and shock testing of the artillery piece; and

- A test facility which simulates dynamic loads and motion for evaluation of tracked and wheeled vehicle suspension systems. Such a simulation might be driven using live simulation data obtained from vehicles traversing over actual test courses.

These are just a representative sample of physical simulations. They can be used throughout the acquisition process at component, subsystem and system level; for evaluating new technologies and early prototypes; replicating field failures and verifying fixes. The data collected from these simulations can also be useful for validating models and simulations at all levels of the hierarchy.

4.5.2 Stimulation

In many instances, the actual signals representing the outside environment to a test article are not available. These signals might represent a radar return from a target, a signal from another weapon system such as between a platform and its weapons, or background noise in the midst of which the system must operate.

Simulations are therefore used to *stimulate* the test article just as if the outside signal was present. These stimulations may come from computer models, virtual simulations or from live instrumented tests. They can be "hard-wired" into the system, or applied in the same manner as in the real environment —e.g. through a sensor system. Stimulators may be used in acquisition to simulate threats or other phenomena either in a HW/ SWIL simulation or a live simulation (test) of a weapon system.

4.5.3 Hardware/Software-In-The-Loop

The HW/SWIL simulations are often described as engineering level simulations. They typically consist of multiple classes of simulations. The HW/SWIL includes actual hardware and software, mathematical models, and external stimuli used together to demonstrate the capability of a system or subsystem to operate within an environment simulating actual conditions. A HW/SWIL simulation has proven to be an important tool in system development, test and operational support.

Figure 4-4 shows a typical HW/SWIL simu-

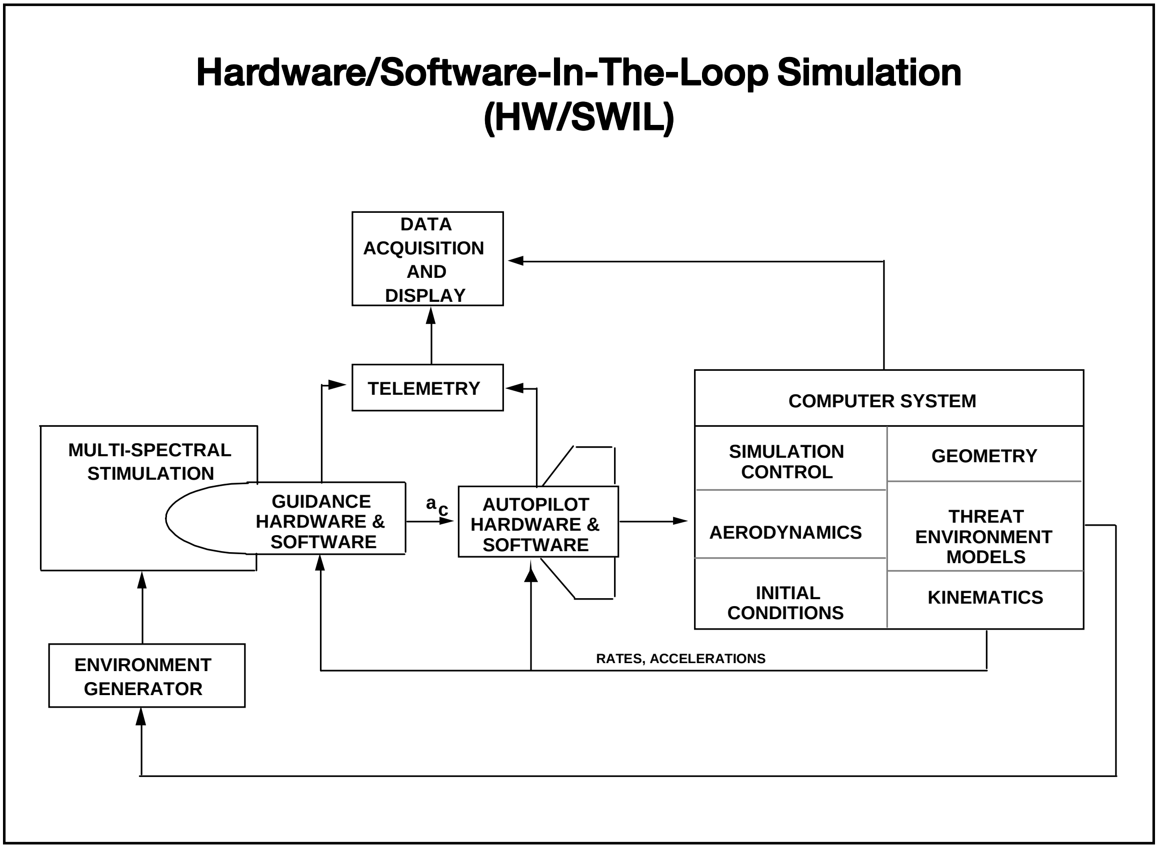


Figure 4-4. Hardware/Software-In-The-Loop Simulation (HW/SWIL)

lation for a missile guidance system. In this example, both the guidance and control section are included in the simulation.[7] The stimulation to the guidance system is a simulated target radar return that the missile would see in operation. Computer models represent the threat environment and provide missile aerodynamics and kinematics which determine the target-to-missile positioning. This HW/SWIL can include the actual hardware, (sensors and processors); software (operational flight program); stimulator (threat simulation); and mathematical models of the missile dynamics—hence, a linkage of multiple types of simulation.

An extension of the missile simulation noted above is the Guided Weapons Evaluation Facility (GWEF) and the Preflight Integration of Munitions and Electronic Systems (PRIMES) facility at Eglin AFB. The GWEF is a HW/SWIL facility used to evaluate weapon performance from launch to target intercept. The PRIMES is a fighter aircraft sized anechoec chamber and associated laboratories supporting one-on-one or many-on-one testing in a flight simulation condition. Linkage of these two simulation facilities provides the capability to simulate weapons on the aircraft; allowing an integrated simulation of target identification, tracking, and missile launch and flight through target intercept.

Another example of the use of HW/SWIL simulators is the Combat System Engineering and Analysis Laboratory (CSEAL) at the Naval Undersea Warfare Center. This simulation facility provides a human interactive prototyping environment to support development, integration, evaluation of combat system technology products and development models for submarine combat systems. It uses the actual hardware and software being evaluated along with realistic simulations of the ocean environment, submarine, weapon systems and threat performance. The CSEAL allows for rapid prototyping, preparation of the prototype for live at-sea trials and timely analysis of the at-sea test data.

The HW/SWIL is important in test and evaluation support, which is discussed in more detail in Chapter 5. In development, HW/SWIL simulation can be used to demonstrate new technology; evaluate designs, concepts, and prototypes; and show the integration of hardware and software. In support of test programs, the HW/SWIL simulations allow for pre-test simulation to identify test conditions. As a risk reduction measure, they are used for checkout of actual hardware and software. These simulations are also used to conduct post test analysis and to fill in a test matrix for conditions which are either not testable or for which no test assets are available. The HW/SWIL simulations allow early identification and correction of developmental problems and allow one to identify and focus live tests (simulations) toward critical issues.

In production and operations support, the HW/SWIL simulation can be used for production lot sampling, P^3I studies and evaluation of changes in operational software programs. With the increasing reliance on software within weapon systems, and regular software changes to enhance or modify performance, HW/SWIL has become a primary tool in verifying the effects of software changes on performance.

Typically, these simulations are run in real-time, with sensors, processors, guidance and control systems operating. Many runs will be performed to obtain statistically significant results for each condition - as an example, approximately 3200 HW/SWIL simulation runs were used to examine a test matrix of 160 conditions for the Sparrow missile[8] (160 cases x 20 simulation runs per case = 3200 simulation runs). Over a period of six years (1976-1982), a total of 39,300 simulation runs were conducted to support ongoing missile development and conduct parametric evaluations.

One challenge for the program office or technical support activity comes about when longer range systems are evaluated. Since these simulations run in real time, longer range systems require more run time: potentially limiting the number of simulation runs that can be performed. Methods to evaluate only critical segments of a mission might need to be pursued requiring in-depth examination of initial conditions for each segment.

Other management considerations which must be integrated into the planning for use of HW/SWIL simulations include:

- Requiring appropriate interfaces (e.g. for signal inputs and outputs) designed into the weapon system component so that it is compatible with the simulation facility and the desired data can be accessed;

- Facility and/or weapon system provisions to allow repeated operation in simulations resulting in usage far exceeding its planned mission time. This may, for example, include provisions for simulation facility supplied cooling of weapon electronics; and

- Simulation facility development efforts which may be necessary to properly support new weapon system technologies or new threats.

4.5.4 Advanced Distributed Simulation (ADS)

The ADS is an emerging form of simulation that has demonstrated the ability to link different types of simulators at dispersed locations; permitting the simulators and their crews to conduct operations on the same simulated battlefield environment.

The term *distributed* refers to geographically separated simulations, each hosted on its own computer without a central computer. These simulations are *interactive*, indicating that simulations or simulators are linked so that they can act upon one another in a common environment (e.g. terrain, ocean, weather, etc.). The linked simulations may be any combination of constructive, virtual and live; and likely to include human-in-the-loop simulations. The infrastructure within which such distributed simulation takes place is termed Distributed Interactive Simulation (DIS), which is discussed further in Chapter 6.

Acquisition-related uses of distributed simulation include advanced concept and technology evaluations within a simulated battlefield environment leading to requirements definition. Performance and requirements trade-offs may also be conducted to define system performance objectives, thresholds, manpower constraints, critical system characteristics and man-machine interfaces. Advanced technology demonstrators, used in conjunction with simulations and live exercises, may allow evaluation of technology, manufacturing and interoperability with other systems prior to major commitment of resources. Distributed simulation might also support test and evaluation planning, test operator training, scenario development, execution (e.g. with additional simulated forces) and post-test evaluation of results.[9]

To date, use of distributed simulation in acquisition has been limited. Two examples cited in 1993 by the Defense Science Board include an operational test of the Non Line-Of-Sight (NLOS) missile and prototyping of M-1 main battle tank upgrades.[10]

The NLOS is a vehicle mounted missile which underwent early operational testing to assess the concept, requirements and hardware; along with its adaptation by forces in engagements against helicopters. This testing required thirteen months and $15.5 million. A parallel evaluation with the use of distributed simulation using an NLOS simulator and helicopter simulators at two different locations and operating on a common terrain database was subsequently conducted. This evaluation was conducted in only 3 months at a cost of $2 million.

In 1984, a test bed (a live simulation) of an upgraded M-1 tank was undertaken. After two years' time and expenditure of $40 million, the simulation was not yet functional. At that time, the simulation was shifted to a modified aircraft dome and successfully completed in six months at a cost of $1 million.

In the future, distributed simulation will certainly increase in capability to support the acquisition process. There has been an increasing emphasis in the M&S community on linkages, within and among, classes of models and simulations. There is a trend toward local networks within given research and development centers along with the aim of making simulations and such networks compatible with the DIS environment to facilitate distributed simulation. To take advantage of this future ADS environment, managers in their M&S planning should consider:

- The potential use of the ADS capability in support of their program activities;
- The likely requirement to make representations of their system available for use in others' scenarios; and
- The incorporation of appropriate data communication standards to address inter-operability requirements of models and simulations they develop.

4.6 Summary

This chapter provided an overview of the classes of models and simulations which may be used during the acquisition life cycle. As shown in Figure 4-5, a program will likely employ a suite of models and simulations. The engineering level models will provide measures of performance along with design, cost, producibility and supportability information for components, subsystems or system. The military utility of the system

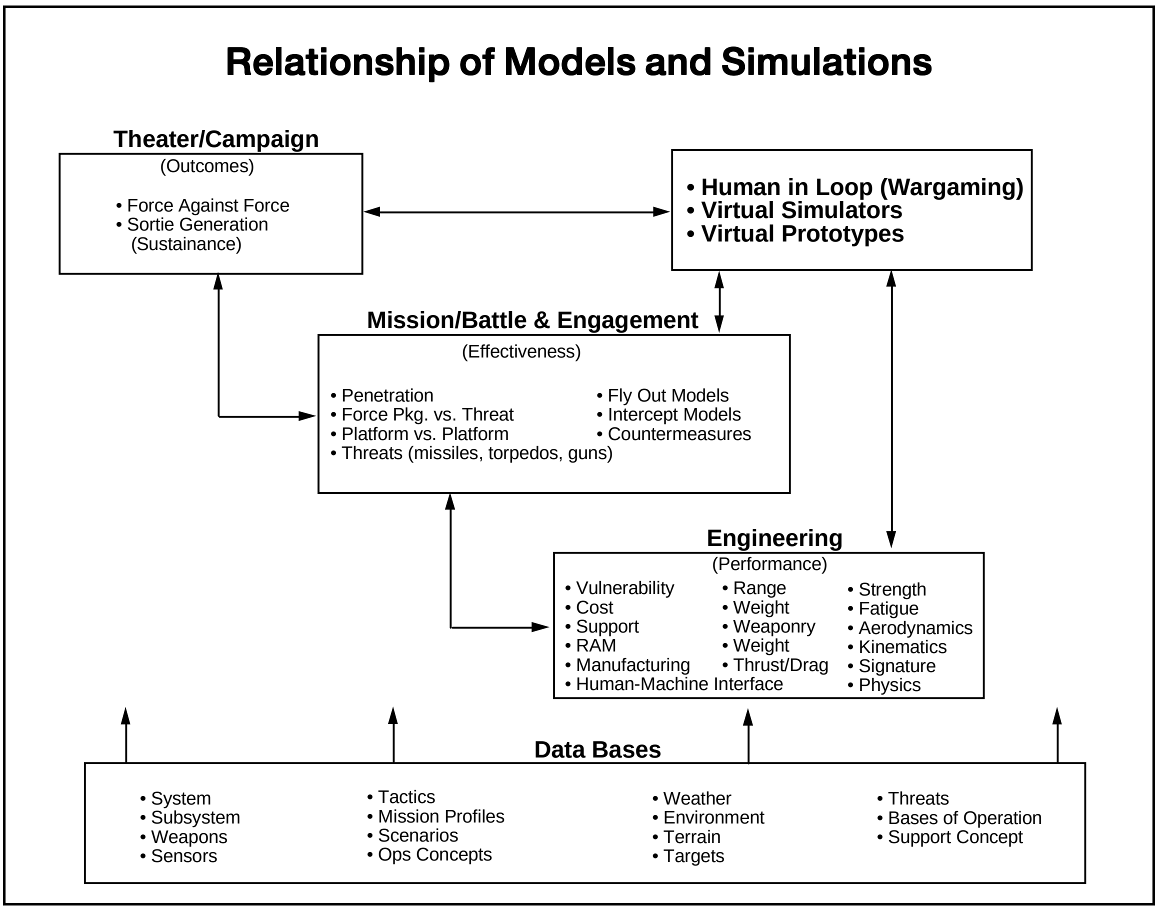


Figure 4-5. Relationships of Models and Simulations

is evaluated within engagement and mission/battle level models which indicate MOE. At the highest level, the outcomes of major conflicts involving combined forces are evaluated within theater/campaign level models. Human-in-the-loop, virtual simulators and virtual prototypes may provide information at all levels of the hierarchy. As in any analysis, the input data and assumptions are major drivers in the results of all simulations. Just some of the system, environment, threat and tactics data requirements are shown in Figure 4-5. The PM should remember that there is no single model or simulation that will suit all of a program's needs. Each model or simulation has a specific purpose for which it is intended and will provide information at the requisite level of detail to support specific activities during the program life cycle.

ENDNOTES

1. Force Structure, Resource, and Assessment Directorate (J-8), The Joint Staff. (1992). *Catalog of Wargaming and Simulation Models* (12th ed.). Washington DC.

2. Note: For those readers who need further information on specific models and simulations, the appendices of this guidebook contain points of contact within each Service, and sources of models and simulations catalogs.

3. Office of the Under Secretary of Defense for Acquisition. (1993). *Impact of Advanced Distributed Simulation on Readiness, Training and Prototyping*. Washington, DC: Report of the Defense Science Board Task Force on Simulation, Readiness, and Prototyping.

4. Garcia, A., Gocke, R. Jr., Johnson, N. (1994) *Virtual Prototyping, Report of the DSMC 1992-1993 Military Research Fellows,* Ft. Belvoir, VA: DSMC p 34.

5. Office of the Under Secretary of Defense for Acquisition. (1993). *Impact of Advanced Distributed Simulation on Readiness, Training and Prototyping*. Washington, DC: Report of the Defense Science Board Task Force on Simulation, Readiness, and Prototyping.

6. *AFMCP 800-66: AFMC Models and Simulations (M&S) Guide* (July 1993). Wright-Patterson AFB, OH: HQ Air Force Materiel Command; Military Operations Research Society. (1989). *Military Modeling* (2d ed.) W. P. Hughes, Jr. (Ed).

7. Adpated from notes provided by Emil J.Eichblatt, Naval Air Warfare Center (Weapons Division), Point Mugu, CA.

8. Eichblatt E. J. Jr. (1983). *Performance Simulation in support of Test and Evaluation.* Point Mugu, CA: Pacific Missile Test Center (now is Naval Air Weapons Center).

9. *Distributed Interactive Simulation Master Plan*. (Draft, 1994). Washington, DC: HQDA, Office of the Assistant Deputy Chief of Staff for Operations and Plans.

10. Office of the Under Secretary of Defense for Acquisition. (1993). *Impact of Advanced Distributed Simulation on Readiness, Training and Prototyping*. Washington, DC: Report of the Defense Science Board Task Force on Simulation, Readiness, and Prototyping.

5

MODELING AND SIMULATION IN SUPPORT OF ACQUISITION

The use of modeling and simulation (M&S) within acquisition is a multi-dimensional activity which:

- supports the milestone decision process;
- supports multiple communities (operator, developer, designer, manufacturer, supporter, tester and trainer); and
- consists of various classes and types of M&S each with a specific purpose.

This chapter provides an overview of how M&S may be used across the phases of acquisition and a discussion of its application to specific acquisition related activities.

5.1 Modeling and Simulation Across the Acquisition Life Cycle

The DoD Directive 5000.1 establishes a disciplined defense acquisition management approach to conducting stable, affordable acquisition programs that meet the user's needs. This management framework includes:

- Evolving broad mission needs into system and subsystem requirements;
- Assessing alternative concepts which eventually develop into a stable, producible design configuration; and
- Establishing initial affordability objectives which evolve into firm unit costs.

The DoD Instruction 5000.2 describes the management policies and procedures which are to be applied throughout the acquisition process and across the functional disciplines. An overview of the process, key activities and M&S application follows.

It is recommended that readers not simply proceed directly to the discussion regarding the particular phase their program currently may be in. Having skipped or already passed a phase in development does not negate the need for conducting those past development and planning activities which can influence the remainder of the program. Therefore, the uses of models and simulations, and the planning activities discussed in conjunction with earlier phases of development, (particularly those described within phase 0), should be reviewed regardless of the current phase of the program.

5.1.1 PRE MS 0

(Ref DoDI 5000.2, pg 3-2 through 3-6)

5.1.1.1 Focus: To determine mission need.

5.1.1.2 Activities: Mission area assessments (MAA) and mission need analyses (MNA) are conducted to examine the ability of existing systems to satisfy mission objectives and analyze capability improvements that are needed to meet deficiencies. Assuming that the deficiency can not be met by a change in doctrine, tactics, operational concepts, training or organization (called "non materiel" solutions) a mission need statement (MNS) will be written describing the validated threat, deficiencies, constraints, and potential alternatives to overcome the deficiency.

5.1.1.3 M&S: As with many other analyses performed in support of a system, there is no single, stand-alone model or simulation to conduct the MAA. A suite of models and simulations, along with supporting data including threat, environment, tactics, etc. are required.

- Engineering level models of new designs provide system and subsystem performance to support higher level models.

- Engagement and mission/battle level simulations evaluate the effectiveness of designs in an operational environment and evaluate the consequences of different engagement tactics.

- Campaign/theater level models examine the outcomes of new system capabilities, technologies, and tactics in extended, combined force conflicts.

- Human interaction in simulations may be used to either identify the tactics for use in other models and simulations, or to examine the operational impacts of alternative tactical schemes or concepts of operation. The reader is reminded of the discussion in Chapter 4 regarding the two uses of human-interactive simulations: determination of decision-making and its effects; and definition of human-machine interfaces. The purpose served here is within the first category.

- Virtual prototypes also demonstrate military utility of new tactics, technologies and systems.

This suite of models and simulations allows for analytical evaluation of tactics or concepts of operation changes with existing baseline systems prior to evaluation of new systems in accordance with DoDI 5000.2.[1] The campaign/theater level models and simulations, used in conjunction with the results of the lower level models, will develop the data used to identify warfighting needs to be documented in the MNS. The engagement and mission level models will identify the features and characteristics that provide the required capabilities with potential to satisfy those needs.

Chapter 1 introduced a "risk cycle" and discussed the concept of "operational risk". The M&S tools used at this time provide insight into that risk and furthermore, are used to identify either non materiel or materiel approaches to mitigate those risks.

5.1.2 Phase 0 - Concept Exploration and Definition (CED)

(Ref DoDI 5000.2, pg 3-7 through 3-9)

5.1.2.1 Focus: To define and evaluate the feasibility of alternative concepts and assess the relative merits of each concept.

5.1.2.2 Activities: During the CED phase, materiel alternatives are examined and a cost and operational effectiveness analysis (COEA) is performed to determine the relative cost effectiveness of those concepts. Operational requirements are defined and documented in an operational requirements document (ORD) and concepts are defined at the system level resulting in a draft system specification. The critical system characteristics and operational constraints are defined, and the initial cost, schedule and performance objectives are developed. High risk areas and risk management approaches are identified. Initial manufacturing and logistics support planning is begun. Training devices are also identified in the ORD produced during this phase. By the end of this phase the system threat is validated and an affordability assessment of the proposed new system is conducted to determine if the proposed new system fits within the Defense Planning Guidance and long range investment plans.[2]

5.1.2.3 M&S: In the CED phase, many of the same classes and types of models and simulations used to define requirements are again employed to examine the capabilities of specific materiel alternatives at the engineering through campaign analysis levels.

- Engineering level models and simulations of proposed technologies and new designs will be used to project performance and examine performance trade-offs. Logistics support models will be used in defining the overall support concept and operations and support costs. Cost models, will be used to determine life cycle costs for use in the program cost estimate, for evaluation of alternatives in the COEA, and to develop a preliminary design to unit production cost objective.

- Engagement and mission/battle models and simulations will be used to determine mission effectiveness measures for the proposed alternatives, again in support of the COEA and ORD development.

- The theater/campaign level models and simulations will be used to evaluate the proposed systems and determine their impact on the outcome of conflicts. These results will support the COEA and ORD, and be used to evaluate how well the proposed system(s) meet the previously identified need.

- Human interactive simulations will continue to be used to develop and examine tactics and decisions within the above framework of constructive models.

- Virtual simulations might be used to evaluate new technologies, system concepts and tactics in a realistic battle environment. This may range from a single simulator to multiple simulators of a new system linked to other friendly and enemy system simulators on a synthetic battlefield.

It is in this phase, that initial program planning takes place and the key program documents which set the stage for the entire program are developed. Consistency should be maintained among all of the acquisition management documentation. This includes the measures of effectiveness, measures of performance, and criteria in the Operational Requirements Document, the cost and operational effectiveness analysis, the Test and Evaluation Master Plan (TEMP) and the acquisition program baseline. Paraphrasing the words of one acquisition manager, "If you cannot show how you intend to relate the measures of effectiveness (MOEs) and measures of performance (MOPs) used across the COEA, ORD, acquisition pro-

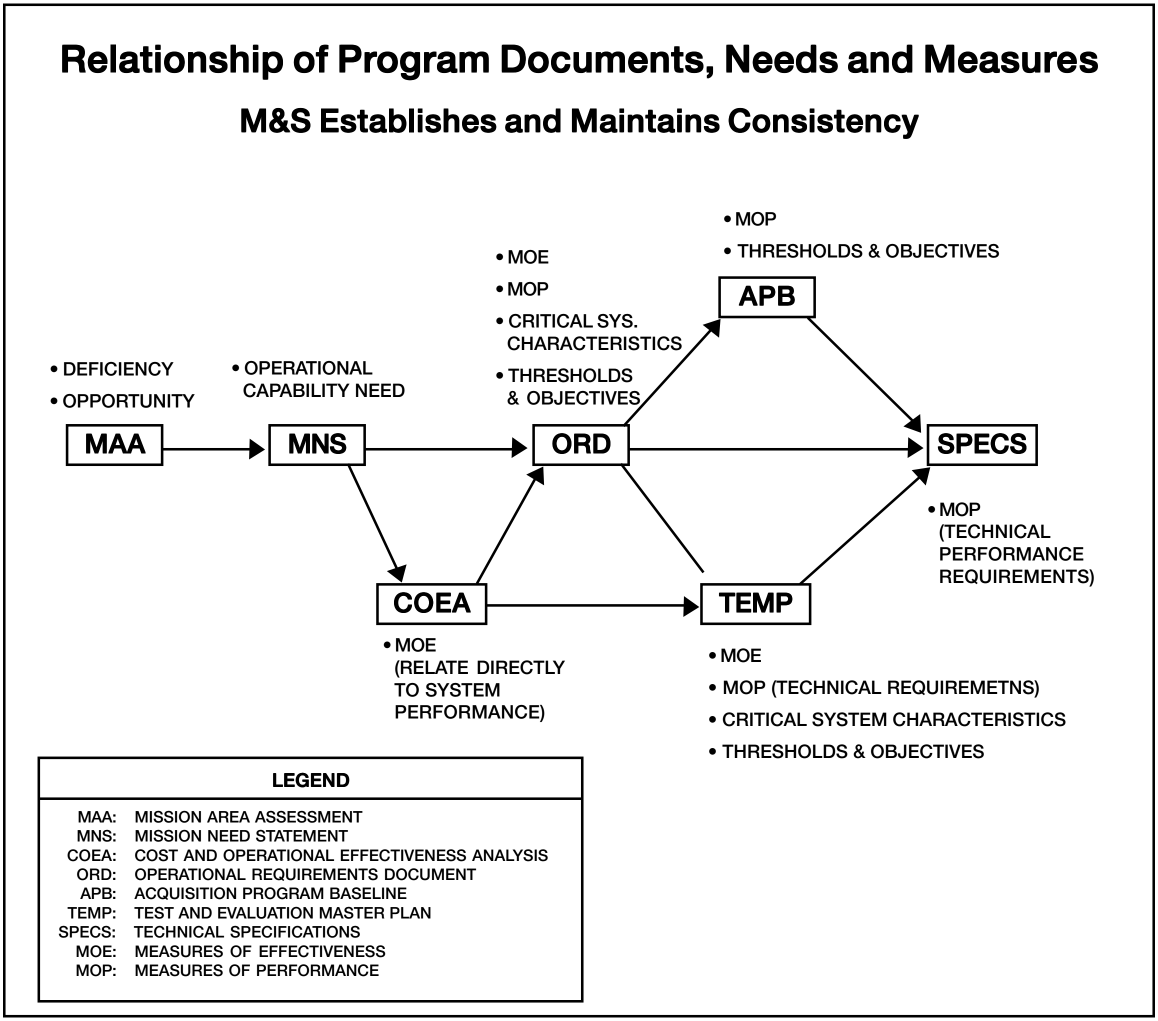


Figure 5-1. Relationship of Program Documents, Needs and Measures

gram baseline (APB), TEMP, as well as to the MNS, then don't bother showing up to the DAB planning meeting." This linkage is depicted in Figure 5-1.

The TEMP, first prepared during this phase, must identify M&S resources which will be used to support development and operational testing.[3] The program office should consider, at this time, how models and simulations will be used across all of the functional disciplines as the appropriate plans (e.g., integrated logistics support plan, systems engineering management plan and manufacturing plan) are developed.

Modeling and simulation is a powerful tool to assist the acquisition manager in establishing and maintaining a consistent relationship among MOEs, MOPs and program documentation. The activities initiated in this phase will continue or be repeated with increasing detail and specificity as the system design matures. The program office must lay the groundwork for continuing application of models and simulations throughout the life cycle. This should include considerations of factors such as use and reuse of models and simulations, integration and interoperability, and common data bases. Planning for model and simulation development should also address future compatibility with the synthetic battlefield through DIS communication standards and the eventual transition or application of developed models and simulations to the training environment. The main objective is to allow the program to later build upon models already developed, thus reducing duplication and providing for consistency through the phases and among the documents and activities within a given phase.

The use of models and simulations can support early risk management activities in the acquisition program. The M&S tools will identify system performance and effectiveness levels required to meet the specified threat. Acquisition managers may use these results to aid in establishing risk levels associated with each of the functional areas (threat, technology, design and engineering, manufacturing, support, cost, and schedule) to be reported within the risk assessment of the integrated program summary.[4] The M&S tools can also support evaluation of system or technology alternatives which may offer reduced risk. From a program planning point of view, models and simulations can serve as a tool to assist in relating the MOP, MOE and integrating program plans, documentation, and functional disciplines, fostering Integrated Product and Process Development (IPPD) at the start of the program.

5.1.3 Phase I - Demonstration and Validation (DemVal)

(Ref DoDI 5000.2, pg 3-13 through 3-15)

5.1.3.1 Focus: To examine multiple design approaches and technologies for system candidates; address supportability, manufacturing, and affordability; and establish performance objectives.

5.1.3.2 Activities: As the system begins to be defined at greater levels of detail, draft development specifications are produced; and the system specification is approved initiating configuration management of the system. Critical design characteristics and performance requirements at the system level are refined and preliminary requirements for subsystems are developed. A new COEA is conducted and program plans and documentation such as the ORD, TEMP, SEMP, and ILSP and acquisition strategy are updated. Critical technologies are demonstrated; and prototyping, testing, and early operational assessment of critical systems, subsystems and components are conducted. Risk areas and management actions will be assessed. Producibility engineering planning is conducted and a preliminary manufacturing plan is produced. Logistics support activities examine factors such as level of repair. These analyses provide a basis for communication between logistics and design engineers as initial design trade-offs are made.

5.1.3.3 M&S: Modeling and simulation in the Demonstration and Validation (DemVal) phase continues to support and extend activities that were initially conducted in CED. During DemVal, as the focus of development starts shifting toward design of subsystems and components, the models and simulations take on better definition. Uses of models and simulations in this phase include:

- Engineering level models and simulations of proposed system and subsystem concepts at increasing levels of detail will be used to provide a better estimate of performance for development of design specifications and for use in other models. Hardware/software-in-the-loop (HW/SWIL) simulations will be used to evaluate brassboard designs, plan prototype tests and to identify and correct problems as a risk reduction measure. Logistics support models such as repair level analyses allow the logistics and design community to investigate the sensitivities of reliability and maintainability, and repair level in concert with design trade-offs.

Computer-aided design (CAD) and computer-aided manufacturing (CAM) models support both design and producibility planning. By the end of this phase, the program office should require factory simulations to support EMD and subsequent proposals for rate production and facilitization.

Cost models will begin to incorporate engineering cost estimates and these will be used to determine life cycle costs in the program cost estimate, to evaluate alternatives in the COEA, and to refine the design to unit production cost estimate.

- Engagement and mission/battle models and simulations will again be used to evaluate mission effectiveness measures for the proposed systems in support of the COEA and ORD. They may also be used to define the interoperability requirements among systems and the impacts of the proposed system on existing weapon systems.

- The theater/campaign level models and simulations will be used to evaluate the proposed system's impact on the outcome of conflicts. These results will support the COEA, and evaluate how well the system meets the requirements stated in the ORD.

- Human interactive simulations will continue to examine tactics within the above framework of constructive models and will begin to examine the human-machine interface in virtual simulations.

- Virtual simulations may be used to evaluate the systems and subsystems and examine tactics in a realistic battle environment. In the DemVal phase, such simulations can employ more detailed performance models and actual prototype HW/SWIL. This may range from a single simulator to multiple simulators of a new system linked to other friendly forces and engaging the enemy on a synthetic battlefield. These linkages may include any combination of virtual simulations, live simulations (exercises), or constructive models of systems and forces. The virtual prototypes will be particularly useful in examining human-machine interfaces and conducting trade-offs without building actual hardware.

During DemVal, the program office should be taking advantage of and implementing the plans for M&S developed during CED. Simulations at various levels may be used in support of the early operational assessments, particularly when little hardware is available for live testing. Simulations can also be used in this phase to assist in source selection. Contractors might be required to bring their hardware into a government simulation facility for evaluation. In some instances, contractors might be provided a copy of the simulations that the government intends to use in system comparisons during source selection.

During this phase, the use of M&S will continue to help the acquisition manager to manage risk. The early use of simulations such as HW/SWIL with brassboard equipment can allow early identification and solution of technical problems. The virtual prototypes with a single common data base which are accessible to all the functional disciplines will facilitate IPPD; and allow better design decisions with less potential for having overlooked impacts to other disciplines.

5.1.4 Phase II - Engineering and Manufacturing Development (EMD)

(Ref DoDI 5000.2, pg 3-20 through 3-22)

5.1.4.1 Focus: To translate the most promising design approach into a stable, producible and affordable design.

5.1.4.2 Activities: The EMD phase includes detailed system, subsystem and component design; including the associated manufacturing and support processes. Testing is conducted to verify that the system meets specification requirements and satisfies mission need and minimum operational performance requirements. Production planning is refined and logistics support activities include provisioning. Low Rate Initial Production (LRIP) late in this phase is conducted to verify producibility and production costs. By the end of this Phase, the system is defined to its lowest levels (individual parts). Initial operational test and evaluation (IOT&E) and live fire testing is completed prior to a decision for full rate production.

5.1.4.3 M&S: A major focus of M&S in EMD is at the engineering level models which are used for design, engineering tradeoffs, test planning and support, subsystem and system performance, and verification of compliance with specifications. Models and simulations also support COEA and ORD updates, DT and OT&E, and prepare for production and deployment of the system.

Several uses of models and simulations in EMD are defined below.

- Engineering level models and simulations of proposed systems and subsystems will be used for detailed design and assembly of subsystems, components and piece parts. Performance requirements will be verified using a combination of testing and simulation.

The HW/SWIL simulations will be used in a model-test-model process for pre-test planning, test execution, and post-test analysis. Such simulations are able to identify problems in actual test hardware before conducting live tests (i.e. live simulations) on the range. They also provide for parameter variation studies, and augment the matrix of test conditions. The performance estimates from simulations during this phase along with live simulation (test) data provide input for models and simulations at other levels or of other classes.

Logistics support models will examine such factors as reliability, availability, maintainability, transportability, and provisioning (spares, support equipment, manpower). The CAD/CAM models will produce designs that can be electronically transmitted to the shop floor resulting in fewer manufacturing errors. Factory simulations are used to plan facilities and equipment and define production flows to meet planned production rates in support of both design and producibility planning. If not already accomplished, the program office should require factory simulations to support proposals to substantiate the ability to achieve rate production and identify required facilitization.

Cost models will be able to incorporate cost data from engineering models and actual LRIP hardware for the program cost estimates and COEA updates.

• Engagement and mission/battle models and simulations will again be used to evaluate how well the designs allow the proposed system to achieve the necessary MOE.

• The theater/campaign level models and simulations will be used to assess the proposed system and determine its impact on the outcome of conflicts.

• Human interactive simulations will continue to examine tactics within the above framework of constructive models, but will more likely focus on continued refinement of human-machine interfaces.

• Virtual simulations can be used to evaluate systems performance and effectiveness. A virtual prototype can be used to support development efforts including design, support (e.g. maintenance walk throughs), manufacturing and training. Members from every functional discipline share the same electronic representation of the system facilitating integrated product and process development. Weapon system trainers being developed should take maximum advantage of the models and simulations used in developing the system itself. As these trainers are developed and made available, they may be used for training test crews, and mission rehearsal for live simulations (e.g. OT&E planning).

• Live simulations may take the form of live exercises, or instrumented prototype tests, including IOT&E. Managers should insist that data obtained in these tests are used to further validate the models and simulations.

A combination of engineering, engagement, mission and campaign simulations, as described in the program TEMP, will be required to augment the developmental and operational test program during EMD. Earlier program efforts to define the appropriate models and simulations; VV&A them; and determine the relationships among MOE and MOP are critical to the successful application of M&S to support or augment the test program.

At the end of EMD, detailed design of the system including definition of production and support processes is complete. In accordance with M&S planning conducted beginning in the CED phase, the program office should be prepared to maintain those models and simulations which will be needed for continued support of the weapon system during its life cycle. The program manager (PM) also needs to consider how to make representations (models) of the system available to others outside the program office that may have a need to use them.

Models and simulations will support detailed design during this phase. They will continue to be key tools for IPPD, and will reduce design risk by allowing all of the functional disciplines to work from the same design data base. A reduced number of engineering change proposals (ECP) will be an important result of this activity. The HW/SWIL simulations will result in significant risk reduction in test and evaluation through planning, hardware checkout and mission rehearsal. Finally, the transition to production will take place with reduced risk by the electronic transfer of digital design data directly to the manufacturing floor.

5.1.5 Phase III - Production and Deployment

(Ref DoDI 5000.2, pg 3-26 & 3-27)

5.1.5.1 Focus: To produce and deploy the system.

5.1.5.2 Activities: The objectives of this phase are to establish a stable, efficient production and support base; conduct follow-on operational test and evaluation (FOT&E); achieve operational capability that satisfies mission need; identify, verify, and incorporate engineering changes; identify operational and/or support problems; and identify the need for major upgrades or modifications requiring an MS IV review.

5.1.5.3 M&S: In the production and deployment phase, models and simulations can be used to support continued testing, verification of design changes, training of crew members and development of operational tactics. Below are some applications for this phase of the program.

- Engineering level models and simulations may be used for evaluation and verification of engineering design changes. The HW/SWIL simulations will continue to be used in a model-test-model process for pretest planning, test execution, and post-test analysis in support of further development testing and FOT&E. They continue to be used to check out actual test hardware and software before conducting live tests (simulations) on the range. Simulations may also be used in production lot sampling or production acceptance as a less expensive alternative to live testing. Logistics support models will incorporate actual field data to determine system readiness.

Factory simulations can evaluate the effects of design and manufacturing process changes on production. They can also provide information on whether current facilities and resources can accommodate changes in production rates or the manufacturer's business base. The support community may also choose to use such simulations in depot planning for weapon system maintenance.

Cost models will have the ability to use actual production cost data and preliminary O&S costs in maintaining oversight of program costs.

- Engagement, mission/battle and theater/campaign level models and simulations may continue to be used to evaluate operational consequences of system performance changes or changes in threat. In the interactive mode, these simulations will be used as wargaming simulations to train battle staffs on new tactics and concepts of operation.

- Virtual simulations, such as weapon system trainers, can be used for training operational crews and mission rehearsal for FOT&E. They can also be used along with other simulations of friendly forces to engage enemy forces on a synthetic battlefield.

- Live simulations will include live exercises, or instrumented prototype tests, such as FOT&E.

With the system being produced and deployed, real data are becoming available for continued validation of the models and simulations used within the program. This is an opportunity to improve the models for future use either in the current program or another program—it is useless to place the data on the shelf and forget about it!

At this point in the program, the program office is implementing the plans for life cycle maintenance of the models and simulations. This is particularly important to keep in mind for weapon system post-deployment support activity.

Within this phase, the use of modeling and simulation will continue to reduce program risk. On the acquisition side, the electronic transmittal of design data to the shop floor will result in fewer manufacturing errors and less rework. The factory should be able to meet production requirements based upon planning using the factory simulations.

From the operational perspective, the weapon system operators will have available a training system which accurately simulates the weapon system and its weapons. It will be able to use models and simulations reflecting the characteristics of its weapons and enemy threats, and even employ the appropriate data protocols so it may interact with other live or simulated entities within a synthetic battlefield environment.

5.1.6 Phase IV - Operations and Support (O&S)

(Ref DoDI 5000.2, pg 3-28 through 3-30)

5.1.6.1 Focus: Insure system continues to meet mission needs and identify shortcomings and deficiencies.

5.1.6.2 Activities: In-service engineering support, implementation of design changes and service life extension programs are an ongoing activity. A change in threat, a deficiency in capability or the opportunity to reduce the cost of ownership (such as via new technology) may result in a decision to seek a major modification approval, milestone IV, for which a COEA will be prepared.

5.1.6.3 M&S: In the O&S phase, models and simulations can be used to support continued testing, verification of design changes, training of crew members, mission rehearsal and development of operational tactics. More importantly, M&S will be used in support of decisions to initiate major modifications of the system and to identify deficiencies.

- Engineering level models and simulations will continue to be used for evaluation and verification of engineering changes. The HW/SWIL simulations will be used to "check out" actual test hardware and software before conducting live tests (simulations) on the range.

For some systems there is a potential for performance to degrade as a result of long term storage. Shelf-life evaluations of systems or components can be conducted via simulation, in lieu of live tests. In this case, engineering level HW/SWIL simulations can evaluate performance of articles after extended storage. The operational impacts, or potential changes in tactics to accommodate performance degradations, can then be evaluated in the higher level models.

Logistics support models will continue to use actual field data to determine system readiness. The support community may choose to use factory simulations to support depot planning for weapon system maintenance, particularly useful when major changes in workload are anticipated.

Cost models will have the ability to use actual production and O&S cost data to maintain oversight of program costs and support a COEA for major modification.

- Engagement, mission/battle and theater/campaign level models and simulations may continue to be used to evaluate operational consequences of system performance changes or changes in threat. In the interactive mode, these simulations will be used as wargaming simulations to train battle staffs on tactics and concepts of operation. More importantly, these models and simulations may be used in identifying deficiencies because of threat changes, or may demonstrate the military utility of new technologies which can lead to a milestone IV decision for major modification approval.

- Virtual simulations will continue to be used for training operational crews and mission rehearsal. They may also be used to examine the potential of new technology applications for system improvement or examine the impact of threat changes within a synthetic battlefield environment with other systems.

- Live simulations will continue to include live exercises, or instrumented tests of the system. With the system in use within its operating environment, either in training or live exercises, real data are available for continued validation of the models and simulations used within the program.

Nearly every weapon system today employs computer software. Software updates to improve capability or to counter a new threat are an ongoing activity for the life of the system. Simulations are the primary method used to test and verify any changes made in the system software. This fact emphasizes the importance of a simulation plan that addresses the use and maintenance of models and simulations throughout the system life cycle.

The "risk cycle" introduced in Chapter 1 has come full circle. The models and simulations will be used to reduce risk in several areas. They will be employed to replicate problems or failures encountered in operations and verify solutions to maintain mission capability. In those instances where performance has degraded over time, for whatever reason, models and simulations will quantify performance impacts and evaluate changes in tactics or employment to accommodate them. Lastly, the suite of models and simulations will identify capability deficiencies because of threat changes and evaluate non materiel and materiel approaches to mitigate the operational risk caused by those deficiencies.

5.1.7 Summary

As the above discussion shows, M&S will be used by a program from the earliest stages through operations and support. Many of the same models, or types of models will be used repeatedly. A significant amount of program planning takes place during phase 0, CED. It is in this early planning stage that M&S should be identified and woven into the appropriate program and functional discipline plans.

5.2 Modeling and Simulation in Support of Acquisition Activities

The remainder of the chapter describes how M&S supports key acquisition functions as they span the phases of the process. These functions are: requirements definition, program management, design and engineering, manufacturing, test and evaluation, logistics support and training. For these functional areas, the reader will find a template in Appendix G showing key activities conducted and the types of models and simulations that might be employed. Those templates should serve as examples to stimulate PMs as they perform the detailed planning for their own programs. In applying M&S to activities described in the remainder of this chapter to their own programs, PMs should look for opportunities in two areas:

• How the program can use the M&S tools across phases of the acquisition process; and

• How the program might make use of M&S to integrate activities across functional boundaries.

5.2.1 Requirements Definition

Chapter 2 provided a detailed discussion of the requirements development process. In this section, we will describe the types of models and simulations that can be used in the process of developing requirements documents (MNS, ORD, specifications). The reader is referred to Figure 5-2 for the following discussion.

As with most other analyses conducted during the acquisition process, a complimentary suite of models and simulations is likely to be used, ranging from engineering performance to theater/campaign levels.

The input data to the analysis process includes ground rules such as:

• Defense Intelligence Agency (DIA) threat estimates along with scenarios and missions derived from the Defense Planning Guidance (DPG);

• Environmental data including weather, terrain, ocean environment, countermeasures, etc.;

• A selection of operational concepts and tactics, which allow for evaluation of potential non- material solutions as required by DoDI 5000.2;

• System options to include existing, upgrades or new systems; and

• New technologies that may be available through DoD's science and technology programs, advanced technology demonstrations or industry.

These data address a variety of scenarios, systems and tactics and will be used in analyses conducted at each level in the M&S hierarchy described in Chapter 4. Using the engineering level of models, analyses provide performance estimates for existing and improved capability systems taking into account the emerging technology opportunities. The performance and design trade-offs of system and subsystem design concepts and technologies are evaluated at this level. These system/subsystem performance capabilities are evaluated within the engagement and mission/battle level models and simulations to determine system effectiveness (e.g. probability of kill, losses, survivability, vulnerability) and mission effectiveness (e.g. loss exchange ratios, probability of engagement) in a limited engagement or mission. These capabilities support campaign level models to examine effects of force mix, tactics or new capabilities on outcomes, typically in terms of force exchange ratios, draw downs or troop movements.

The analyses are repeated for a variety of operational concepts and each of the system options under consideration. The engagement, mission and campaign models may be run iteratively to provide statistical significance to the outcomes. Material capability needs are identified and documented in a MNS.

The engineering models in conjunction with the engagement and mission/battle level models also provide the basis for the description of broad capabilities and technology developments which should be studied in CED.

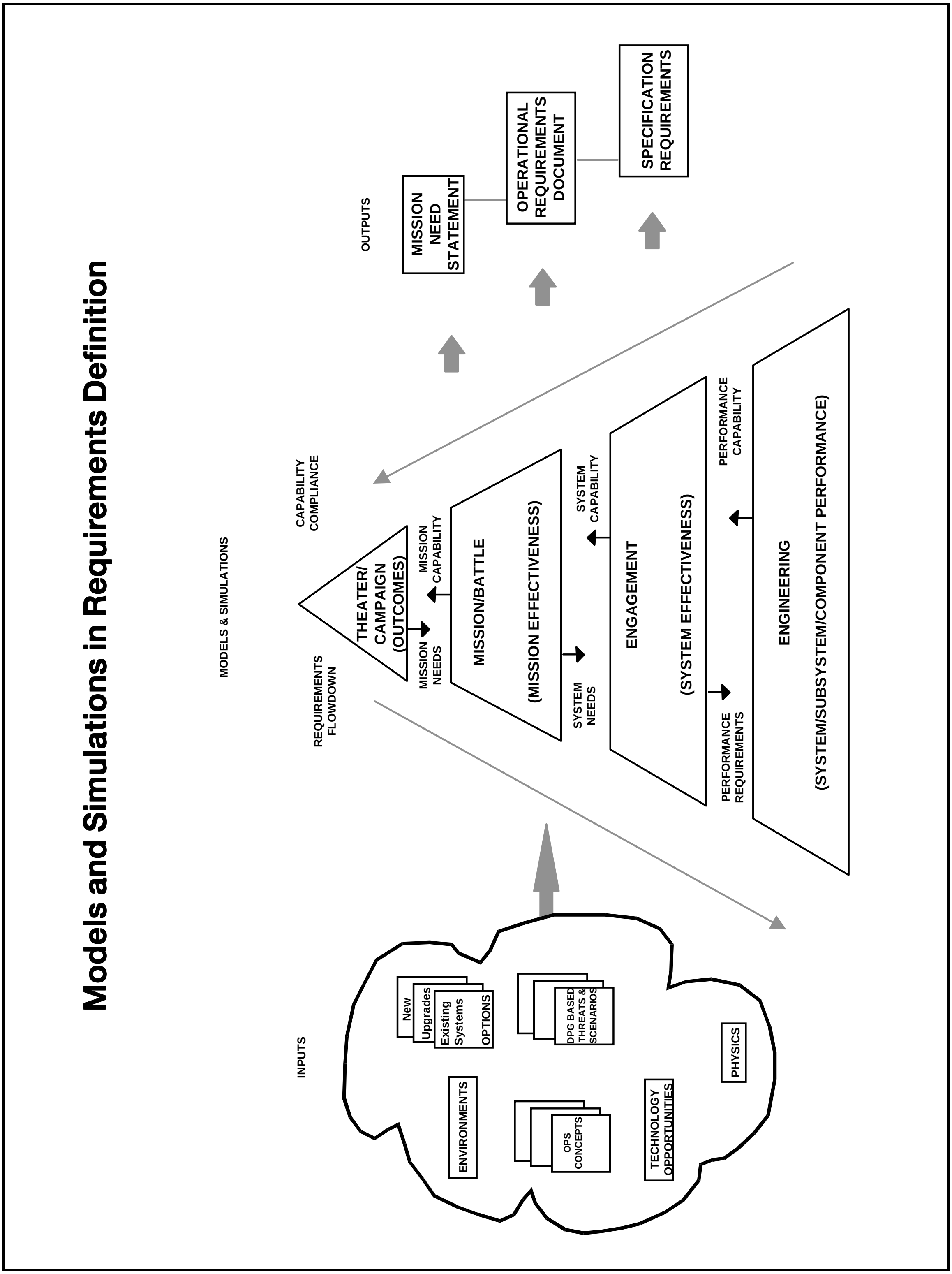


Figure 5-2. Models and Simulations in Requirements Definition

The ORD will be developed during the CED phase. The ORD defines thresholds and objectives in terms of operational effectiveness measures, system performance measures and critical system characteristics. The ORD will be updated during DemVal with refined and more detailed capabilities and characteristics. It is likely that mission/battle and engagement models, in conjunction with engineering models, will be used to develop the effectiveness and performance measures for the ORD.

Technical specifications similarly evolve. A draft system level specification will be developed during CED; development specifications will be written during DemVal; and product, process and material specifications during EMD. Engineering level M&S (e.g. design, support, manufacturing and HW/SWIL) typically support the development of these requirements specifications.

There is not a simple one-to-one mapping between a particular level of M&S and a particular requirements document. Rather, as was discussed in Chapter 4, a combination of M&S (levels and classes) will likely be needed to generate the various measures and insure consistency of those measures across the program documents.

5.2.2 Program Management

The PM is faced with balancing cost, schedule and performance objectives throughout the program. Much of the current emphasis in M&S is on the performance or military utility arena, as has been the focus of much of this guidebook. This next section will touch upon some of the management tools that are in existence.

5.2.2.1 Program Management Tools

Many models used for program management are actually data base references, or knowledge-based tools. Examples of two such management tools are the Navy's Program Manager's Work Station (PMWS)[5] and the Air Force Acquisition Model (AFAM)[6]. These will be discussed, followed by some guidelines on the use of cost models.

Program Manager's Work Station (PMWS) is a series of interrelated software tools designed to provide acquisition information (primarily engineering process oriented) to the user. Three of the modules may be of particular use to the program office:

- Know-how: an automated handbook system that is reported to reduce search time in handbooks and manuals such as the DoD-5000 series, Best Practices (NAVSO-P-6071) and ISO 9000.

- Technical Risk Identification and Mitigation System (TRIMS): based on the Best Practices (NAVSO-P-6071) it allows the user to develop risk metrics and status.

- Best Manufacturing Practices data base: Contains over 1800 abstracts from companies documenting best practices.

Air Force Acquisition Model (AFAM) is an acquisition process model designed to facilitate the process for major and non-major acquisition programs. This personal computer based model addresses activities across the acquisition phases.

- Acquisition Guides and Insights: Procedures which cover 2200 acquisition tasks based on the DoD 5000 series and best management practices and lessons learned.

- Acquisition Management Tools: Provides guidance, task relationships, timelines and expertise from actual program experience which one should tailor before using in a specific program.

The PMWS and AFAM are but two examples of program management tools which provide PMs with a disciplined thought process. They should serve to prompt PMs regarding activities that should be performed and application of best practices.

5.2.2.2 Cost Models

Program managers develop cost estimates during the acquisition process for two purposes:

- Program life cycle cost estimates; and

- Cost estimates for alternatives evaluation in the COEA.

Two separate cost estimates are required from the DoD component in support of milestone I and subsequent reviews. One of these estimates will be prepared by the program office and the other by a separate organization that does not report through the acquisition chain.[7] Additionally, the OSD Cost Analysis Improvement Group (CAIG) will develop an independent DoD estimate and prepare a report to the Under Secretary of Defense for Acquisition and Technology (USD(A&T)) for ACAT ID programs, and to the DoD Component Acquisition Executive for ACAT IC programs.

The second use of cost estimates is in the preparation of the COEA to support milestone decisions beginning with milestone I. The COEA is prepared by an independent activity within the component, and should aid decision-makers in judging which, if any, of the proposed alternatives to the current program offer sufficient military benefit to be worth the cost.[8]

We will not address specific cost models used throughout DoD in this guidebook, however, some general features of a cost model might include:

- Cost estimating relationships
- Statistics package
- Ability to address various cost estimating methodologies
- Learning curve calculations
- Risk analysis
- Sensitivity analyses
- System Work Breakdown Structure (WBS)
- Multiple appropriations (R&D, Appropriations, O&S)
- Time-phasing of costs
- Overhead rates
- Inflation indices.

The above features are contained in the Automated Cost Estimating-Integrated Tools (ACE-IT),[9] which is a framework within which the analyst can develop a cost model. These features are shown only as an illustration of what might be addressed in a cost model, and are not necessarily all-inclusive nor must any particular model contain all those features.

The Office of the Secretary of Defense (OSD) Cost Analysis Guide provides some guidelines regarding the characteristics of a good model for O&S costing which, with tailoring, might be useful for any model application.[10]

- Consistency in cost element structure: The basic cost structure should not change as a system passes through the acquisition phases. However, the basic elements and their sub-elements should be expanded to capture greater levels of detail.

- Consistency in data elements: Data elements of the proposed system should be consistent with those of operational systems for which actual data exists. This allows the costs and cost driving parameters of the reference and proposed system to be compared.

• Flexibility in estimating techniques: The estimating techniques should be allowed to vary as a program progresses through the various acquisition phases.

• Simplicity: Complexity is not desirable in an O&S cost model. Models should be structured in a way that allows them to accommodate more detailed information as a program progresses through the life cycle.

• Usefulness to the Design process: While estimating costs for a CAIG review is an important function, a model's applicability to day-to-day program office and contractor decision making is equally important.

• Completeness: The model should capture all significant costs that will be incurred by the weapon system over its useful life.

• Validity: The model should provide sound, reproducible results for its intended application.

The PM should recognize that in actual practice, cost estimating is a melding of art and science. There is no "one model fits all", but rather typically a custom model for each program, relying on various cost methodologies or historical data bases to address different elements of the system. As with any other M&S efforts, an experienced analyst is key to obtaining credible results.

The Cost Analysis Requirements Document (CARD) describes the system and salient features of the program which will be used to develop life cycle cost estimates.[11] It provides a description of the system and its key characteristics (weight, size, payload, speed, power, etc.) for each WBS element. The CARD addresses the operational concept, risk, quantities, manpower, system usage rates, schedules, acquisition strategy, development plans and facilities requirements. Since the CARD addresses all the key cost elements of the system, it provides the basis for cost estimating and the use of cost models.

A study being conducted by the Army Cost and Economic Analysis Center will provide the results of a survey on cost models used throughout DoD, and may be of interest to PMs.[12]

5.2.3 Design and Engineering

The use of M&S is most prevalent in this functional discipline. A visible example is the Boeing 777 aircraft. This is the first airplane designed solely by computer which was accomplished largely via the CATIA (Computer Aided Three Dimensional Interactive Application)[13] system. Significant accomplishments of this effort included:

• "Paperless" design - the blueprints resided in the computer;

• Design/build teams shared the same design information contained in the computer data base. 2200 networked work stations allowed all of the functional disciplines (e.g. Users, Design, Manufacturing, Maintenance) to communicate based on a common frame of reference;

• The 3-D "virtual airplane" allowed engineers to make design changes and visualize the results, such as component interferences; and

• Design data transferred electronically to the manufacturing floor.[14]

The results of this approach included more than a 50 percent reduction in change error and rework in manufacturing.[15]

Modeling and simulation pervades the various specialty disciplines involved with design—ranging from finite element analysis for structural design, to computational fluid dynamics for aerodynamics or hydrodynamics. For human factors, anthropometric models such as "Jack" can be used to examine the ability of a crew member to operate controls, repair equipment or fit within crew compartments. What these models and simulations offer is the ability to modify designs, analyze the effects and refine the design repeatedly prior to building a single hardware prototype.

In the future, with the integration of design and performance simulation models, one can achieve a "Simulation Based Design"[16] in which 3-D virtual prototypes, properly representing both design and performance, function realistically in a virtual environment and replace actual hardware mockups. Figure 5-3 depicts the process whereby all of the functional disciplines will use the same virtual prototype to support activities across the system life cycle—from operational requirements generation through engineering,

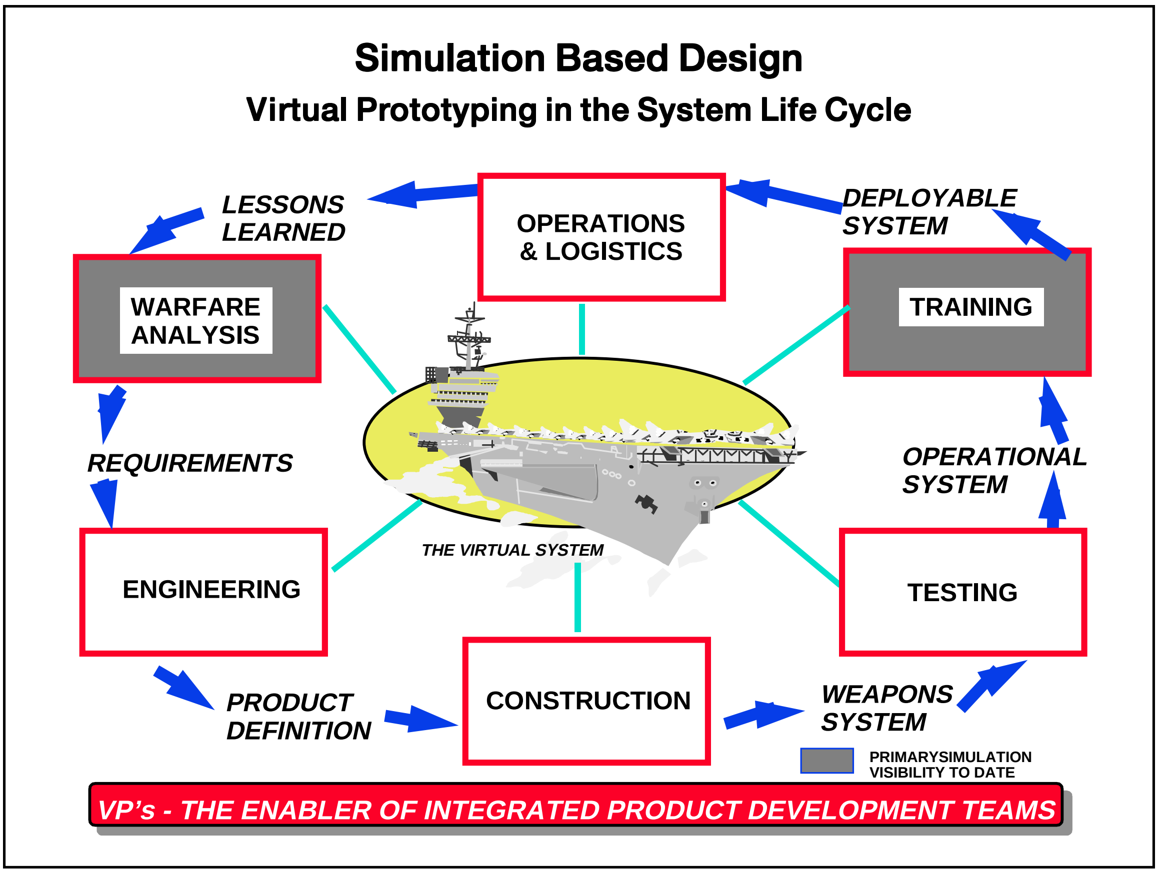


Figure 5-3. Simulation Based Design

construction, testing, training and operations and logistics support.[17] The reader will see another example of the use of virtual prototyping in vehicle design in Chapter 8.

5.2.4 Manufacturing

Producibility is intimately linked with product design—shape, features, materials, etc.. The use of computer models to simulate manufacturing processes such as metal forming, machining and casting allows one to evaluate the ability to produce a design before actually "bending metal". The use of CAD/CAM models allows the design and manufacturing communities to converge on a producible design that meets the requirement. Using the same models and simulations for design and manufacturing, combined with the transfer of digital design data bases directly to the manufacturing floor; reduces errors, rework and hence, production risk.

In addition to having a producible design, the program office must be assured that the necessary capability/capacity is available to meet planned production rates.

In the CED phase, production planning begins with an industrial base analysis. Considerations incldue the investments necessary for industrial capabilities to provide and sustain production; tooling; and facilities.[18] During the DemVal phase, an initial manufacturing plan is developed to portray the facilities, tooling and personnel resources required for production.[19] This plan is updated during the EMD phase based upon the planned detailed manufacturing operations. In production readiness reviews, conducted during EMD, the program management office (PMO) will evaluate the capacity of the production facility to meet the required production rates. The PMO will also evaluated the contractor's production planning, including manufacturing methods and processes, facilities, equipment and tooling, and plant layout.[20]

Factory simulations are used to aid in this cycle of production planning which can support the activities mentioned above. These simulation tools can address production processes, factory process flow, statistical variation in manufacturing operations, equipment, plant layout and manpower requirements to meet production demands. Military and commercial programs are turning to such tools to improve efficiency or determine facilitization requirements. These tools may be used for planning a new production activity, or to examine changes to an existing program. An example follows showing the use of simulation to plan changes in the periodic maintenance of C-141 aircraft.[21]

In this case, the periodic depot maintenance (PDM) of the C-141 aircraft fleet was impacted when two structural problems were discovered: wing and center wing box cracks. Repair of the wing cracks and replacement of the center wing box needed to be incorporated into the ongoing PDM of the aircraft. Furthermore, replacement of the center wing box was a new process for the depot - it had only been done once on a prototype aircraft at a contractor's facility. The SLAM II simulation language was used to simulate the ongoing PDM along with the introduction of the wing repair and center box replacement. A sample of the results of this simulation include:

- An achievable schedule for wing box replacement, but a shortfall for wing crack repair;
- Bottleneck locations; and

• The preference to reallocate rather than purchase additional inspection equipment.

Commercially available and industry owned factory simulations are in use by many weapon system contractors or maintenance depots today. Factory simulations such as "Witness"[22] are now being regularly used to support aircraft, missiles, and electronics production, and depot activities. A listing of commercially available manufacturing related simulation programs can be found in reference.[23]

Factory simulations can be used for the following:

• Develop an assembly strategy;

• Graphically model the assembly sequence;

• Develop and validate work sequences;

• Develop and validate manufacturing process plans;

• Model the factory floor, including facilities and equipment;

• Identify what is achievable in terms of cost and schedule;

• Identify bottlenecks;

• Compare different manufacturing strategies; and

• Identify impacts of engineering changes, new materials, machines or processes.[24]

All of these factors are important in determining the robustness of production planning in proposal evaluation, or eventually, readiness for production. Their use by the contractors, beginning no later than the DemVal phase can ensure the program office that proper production planning has been accomplished.

The Air Force has initiated a policy regarding the use of factory simulations in support of depot upgrades. In November 1992, a policy letter was written establishing the requirement that all depot maintenance sponsored military construction projects or equipment projects greater than $0.5M shall be modeled as a prerequisite to funding.[25]

The use of M&S in manufacturing is aiming toward a future "Virtual Manufacturing" environment. In this approach, the operational requirements identified in the synthetic battlefield environment are translated into design concepts using three-dimensional virtual simulations incorporating geometry and performance. These designs are passed along to a network of distributed manufacturing simulations which may reside throughout a vendor base (i.e. prime contractor and its subcontractors) to identify the manufacturing processes, facilities and tooling requirements. This vendor base is closest to the manufacturing processes and is in the best position to develop cost and schedule estimates. These estimates may then be fed back up to provide better estimates of costs and schedules to support trade-offs and the system level alternative evaluations in the COEA.

The virtual manufacturing initiative is intended to provide the ties between new product design concepts and the processes necessary to manufacture them starting in the earliest phases of development. This will:

• Provide quick and improved cost and

delivery estimates;

• Smooth the transition of new process technologies into production facilities;

• Facilitate lean or agile manufacturing; and

• Facilitate IPPD.[26]

5.2.5 Test and Evaluation

The purpose of a test and evaluation program is to provide information for risk assessment and decision making, verify attainment of technical performance specifications and objectives, and verify that systems are operationally effective and suitable for their intended use. Test planning begins in Phase 0, CED, resulting in the initial TEMP at milestone I. Models and simulations supporting the development (DT) or operational test (OT) programs must be discussed in the TEMP. For DT, the program must "List all models and simulations to be used and explain the rationale for their use"[27]. For OT, the TEMP must "Identify planned sources of information (e.g., development testing, testing of related systems, modeling, simulation, etc.) that may be used by the operational test agency to supplement this phase of operational test and evaluation.

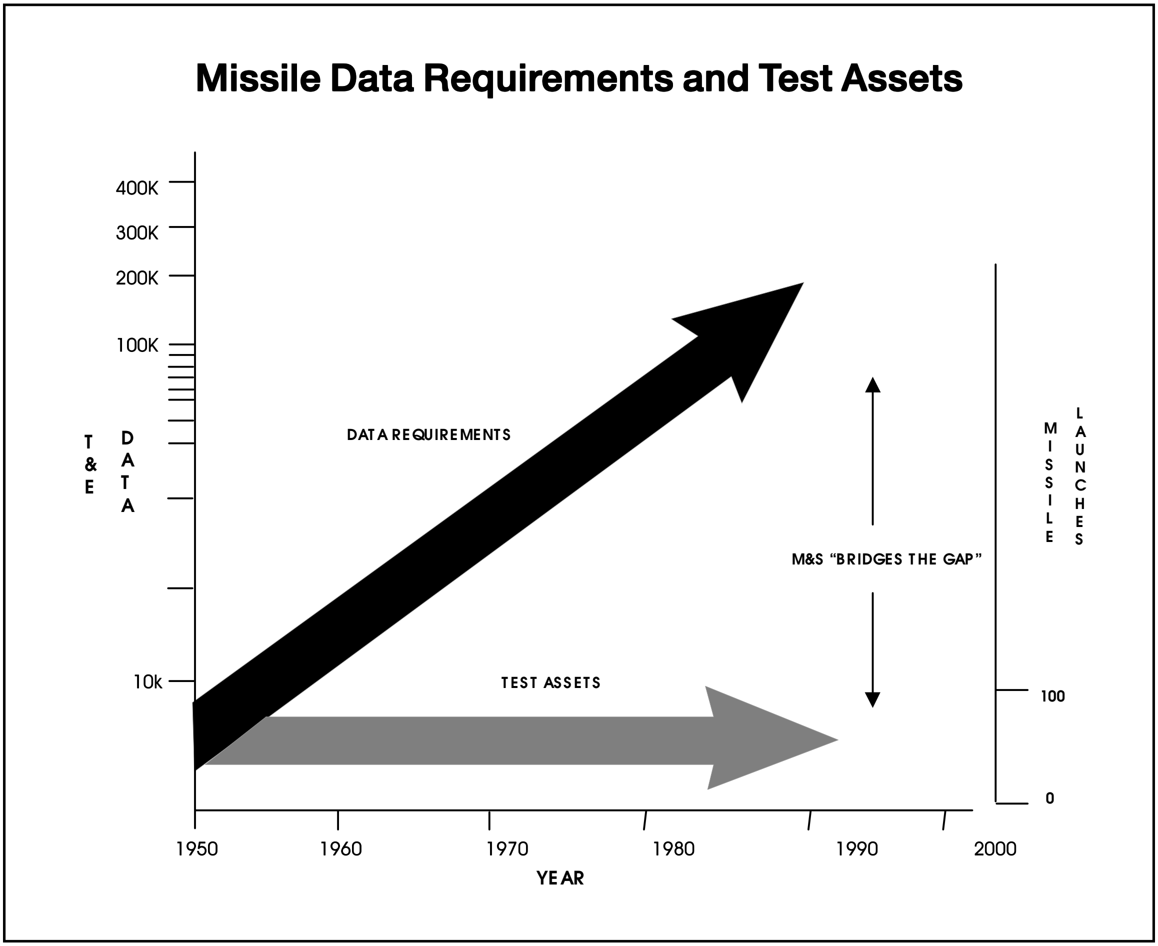


Figure 5-4. Missle Data Requirements and Test Assets

Whenever models and simulations are to be used, explain the rationale for their credible use".[28]

5.2.5.1 Developmental Test and Evaluation (DT&E)

Weapon systems being developed today are increasingly more complex—technology is advancing, the ability to process more information is rapidly growing and the performance of systems is increasing. As an example, consider the illustration in Figure 5-4[29] of available test assets and data requirements for missile development programs over the last 40 years. There has been a significant increase in missile complexity and data requirements, but this increase in missile complexity has not been accompanied by a corresponding increase in missile launch assets—because of tighter program cost and schedule constraints.

Figure 5-5 illustrates this example further.[30] This figure summarizes the number of test firings for several Sidewinder models (AIM-9 series missile) developed over the last 30 years. Most of the upgrades represent what would now be called pre-planned product improvements, involving changes only to the missile seeker. (The exception was the AIM-9L which included a new warhead and fuse along with seeker improvements.) The firings shown represent the total number of firings from research and development through OT&E. The downward trend was driven by cost and schedule. Simulations were used to maintain or increase the level of understanding of system performance even though test need decreased.

Simulations, therefore, are used to "bridge the gap" between the ever-increasing data requirements and the relatively constant, or even decreasing available test assets. Specifically, simulations can be used for:

- *Pre-test planning* – Insuring that the tests to be conducted are, indeed, the most critical and verify instrumentation plans. Simulations can be used to identify the critical test points on which to focus the live tests. Data from the simulation can be used prior to actual testing to check out and exercise the data reduction processes.

Sidewinder Firing History

Sidewinder Model	Development Time	Number of Firings
AIM-9D	1960-1964	129
AIM-9L	1972-1975	69
AIM-9M	1978-1981	35
AIM-9-8/9	1991-1993	21

Figure 5-5. Sidewinder Firing History

• *Mission rehearsal* - "Walking through" the test from initial launch conditions to give confidence that tests will be successful. One can use actual hardware in captive carry being stimulated with threat simulators to check out the system and tactics prior to test.

• *Post-test analysis* - Taking the raw test data and extracting the critical performance parameters.

• *Augment actual tests* - Running large numbers of simulations over many conditions for which test assets are unavailable or when environmental, political, resource or safety constraints make testing infeasible. For example, over a six month period for one missile, a total of 4,280 HWIL simulation runs versus 7 actual launches were conducted.[31]

• *Risk Reduction* - Conducting simulations to reduce program "political" and technical risks.

— *Political risk reduction* – Programs are increasingly under scrutiny from all levels, and managers can ill afford the risk of a live test failure. Simulations to conduct mission rehearsals and checkout of the actual test items can reduce this risk.

— *Technical risk reduction* – Simulations allow developers to evaluate far more design alternatives over more conditions in shorter time periods than live tests. This allows identification and correction of technical problems early in a program; resulting in a design that better meets technical and operational requirements. An example of this latter case is the use of HW/SWIL simulations.

Guidelines on the use of M&S in support of DT&E may be found in the Modeling and Simulation Master Plan[32] prepared by the US Army Test and Evaluation Command (TECOM). This plan discusses the roles of the various participants in Army T&E activities, and provides a vision for the advancement of M&S to increase the efficiency and cost effectiveness of T&E.

5.2.5.2 Operational Test and Evaluation (OT&E)

An OT&E is a comprehensive process which uses analytical studies, analysis, component tests and actual weapon system tests in a complimentary manner. In accordance with Title 10, U.S. Code, "The term operational test and evaluation… does not include an operational assessment based exclusively on (a) computer modeling; (b) simulation; or (c) an analysis of system requirements, engineering proposals, design specifications, or any other information contained in program documents."[33]

However, this does not mean that models and simulations do not have a role in OT&E. Constraints on testing such as cost, security, safety, ability to portray threats, treaty constraints, limitations on test instrumentation, number/maturity of test articles, test space and lack of representative terrain or weather may preclude a comprehensive evaluation based on field testing alone. M&S tools can augment or complement the actual field tests to provide decision-makers with needed information which otherwise would not be available.

According to DOT&E Policy, dated 24 Jan 1989, appropriate uses of M&S include test planning; test data analysis and evaluation to augment, extend or enhance test results; tactics development; and early operational assessments of expected capabilities.[34]

Specifically, the policy states: "Ideally, the user, developer, and tester would agree on the M&S needed for operationally-oriented assessments for a system under consideration not later than Milestone I." This policy also reiterates the importance of describing plans in the TEMP for the use of models and simulations in OT&E to augment, extend or enhance field test results.

Credibility is a key part of successful use of the M&S in supporting OT&E. This includes an acceptable M&S approach; confidence in the models, users, methodology, and results; and a robust VV&A process. Appendix B of the DTO&E policy provides a list of issues that should be addressed to provide evidence of credible models and simulations in OT&E. The reader is also referred to further discussion of credibility contained in Chapter 6 of this guidebook.

The Service's operational test agency is accountable for the OT results that they report and, hence, results of any M&S it uses in support of OT&E. As an example, the Army's guidance on M&S to support OT identifies the Commander of Army Operational Test and Evaluation Command (OPTEC) as the accrediting official for models and simulations used within that organization.[35] Although no formal documentation was found, discussions with the Air Force and Navy OT&E agencies imply that the same policy is followed within the other Services.

In the future, the test community, using advanced distributed simulation (ADS), will be able to conduct live tests which are networked to geographically dispersed human-in-the-loop simulations within a synthetic environment. This provides for a realistic test/simulation in a war-like environment with a variety of friendly and hostile combatants. Currently, in the OT&E environment, distributed simulation is more useful in test planning than actual conduct of tests because of issues such as VV&A of entities within a distributed environment.

A Joint Advanced Distributed Simulation Joint Feasibility Study (JADS/JFS) is currently underway to address issues, principles, procedures and practices for the increased use of distributed simulation support to both developmental and operational tests and evaluations.[36]

5.2.5.3 Live Fire Testing (LFT)

Title 10 of the US Code[37] requires realistic survivability testing of covered systems (or product improvement programs) and lethality testing for major munitions programs prior to proceeding beyond low rate initial production. Examples of M&S supporting LFT include: aircraft and missile flight path generation; detection, tracking, and shooting performance of artillery; warhead-target fragment interactions; penetration mechanics and failure mode analysis.

Evaluations of materials, fuel system design, internal routing of lines and cables, etc. are accomplished using models and simulations which can facilitate "design for survivability" early in development before hardware is produced and tested. The Survivability/ Vulnerability Information Analysis Center (SURVIAC)[38] is a centralized information resource for information on survivability and lethality. The SURVIAC has an inventory of models and simulations and can provide program with technical advice.

The acquisition manager should recognize that the use of M&S complements the T&E activities. It has been recommended that an integrated model-test-model approach be implemented in development programs with three aims in mind:

- Ensure models and simulations still meet the developer's needs;

- Use models and simulations to identify critical tests, data requirements, analyze data and reduce the amount of actual testing; and

- Ensure every test serves the dual purpose of evaluating system performance and validating the models and simulations.[39]

Such an approach has been common in electronic combat system development programs. These development programs employ heavy use of models and simulations prior to testing within integration laboratories, simulation facilities and finally, in the open-air. Testing is then followed by further modeling to analyze test data and extract the MOP and MOE.[40]

This concept of model-test-model is applicable to all system development programs and an adaptation of the above two philosophies is illustrated in Figure 5-6.

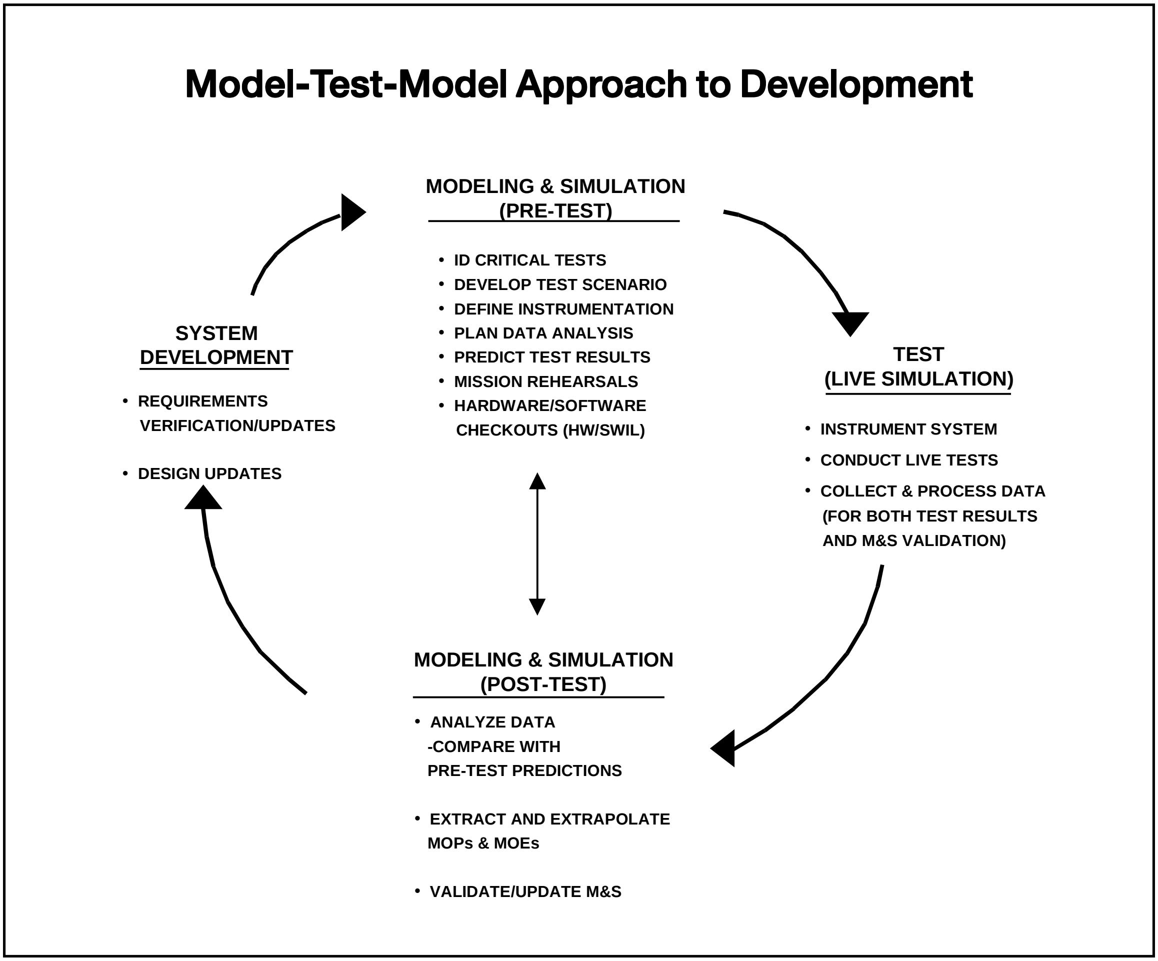


Figure 5-6. Model-Test-Model Approach to Development

5.2.6 Logistics Support

Models and simulations support logistics analyses across the system life cycle—from defining system level supportability concepts to reliability, availability and maintainability design requirements—and eventually modeling actual operational capability during operations and support.

An overview of the way in which M&S can be used to support logistics follows.[41]

Early activities in the logistics community include building the baseline comparison system which can be used along with M&S to do a comparative analysis for the proposed new system; identify supportability, cost, and readiness drivers; and estimate the operations and support portion of the life cycle costs.

In DemVal, as the weapon system becomes more defined at the subsystem level, level of repair analysis (LORA) models are used to identify candidate areas for interface between logistics and design. These analyses help define trade-offs in manpower; reliability, availability, and maintainability; and alternate maintenance concepts and their effects on supportability for specific subassemblies. Using these models to quantify the impacts on support, the logisticians can interface with the designers to produce designs that lead to reduced overall support costs. The LORA models will then be used for the actual repair level decision-making and form the basis for the system maintenance plan.

In EMD, models will be used to analyze repair tasks and identify the requirements in the ILS elements for each component. The results of these analyses form a data repository, the Logistics Support Analysis Records (LSARs), which can be used in the detailed identification of logistics resource requirements for each element of logistics, as well as projected readiness modeling. Among the models used are provisioning models to determine initial spares requirements and the optimum spare parts and quantities necessary to attain end item operational availability at the least cost.

Early in development, engineering estimates of component failure rates are used in the models. As the system matures and is eventually fielded, test data and actual operational data become available. This data replaces the initial estimates on failure and repair in the LSARs. During O&S, this information can be used in models and simulations to evaluate actual system readiness, adjust provisioning levels or support system operational planning. Models and simulations also find use in this phase to evaluate the supportability impacts of proposed ECPs or modifications to the system.

The ILS elements and logistics support analysis (LSA) tasks are supported by an assortment of models or simulations. One source of information on these models and simulations is the "Logistic Support Analysis Techniques Guide".[42] This guide is prepared by U.S. Army Materiel Command Logistics Support Agency (LOGSA), which is designated as the DoD lead agency for LSA.[43] This guide contains descriptions of 105 models or simulations cross referenced to LSA tasks and ILS elements, along with points of contact for each model.

Another source of information is the Supportability Investment Decision Information Analysis Center (SIDAC) which maintains a small number of logistics models and can provide assistance in preparing and running those models and using assorted logistics related data bases.[44]

5.2.7 Training

Training is integral to achieving and maintaining force readiness. Despite reductions in force structure and annual operating funds, the services are determined to maintain their "warfighting edge" with superior training. Throughout DoD, simulation in support of training spans all of the classes of simulation.

Wargaming is used to train battle staff in planning and execution of tactics from individual system level through combined assets applications. This is often accomplished using constructive models representing systems or groups of systems or may even be linked to live systems. Facilities which support such simulations may allow multiple participants to interact and provide recording of events for subsequent data analysis and debriefing of participants.

Virtual simulators such as weapon system simulators (aircraft, tank, ship, etc.) are commonly used for training. These simulators immerse operators in a realistic environment (visual, aural, motion) allowing them to perform a mission as if they were in the actual vehicle, thereby receiving combat realistic training. Another example of immersing the operator in a virtual environment might be an air defense simulator which allows operators at multiple consoles to track, identify, allocate and control weapons using command and control formats obtained from other simulated platforms. Weapon characteristics might be provided via computer generated weapon simulations.

Live simulations in support of training include the Army National Training Center at Ft. Irwin, the Navy "Strike University" at Fallon Naval Air Station, the Air Force "Red Flag" at Nellis AFB, and the Marine Corps Air-Ground Combat Center at Twentynine Palms. These simulations allow participants to operate systems under environmental conditions which approach real life in combat. Data gathered during instrumented exercises can be used to debrief participants, and can provide the system acquisition community valuable information on performance of weapon systems and human interaction during close to real combat conditions.

The future application of simulation to training will involve a combination of live and virtual participants within synthetic environments and will allow for training with individual participants geographically distributed. This will become a reality in the training community when the Navy/Air Force Joint Tactical Combat Training System (JTCTS), the Navy Battle Force Tactical Training (BFTT) System, and the Army's Close Combat Tactical Trainer (CCTT) are fielded.

The JTCTS is a training instrumentation system that will revolutionize the way the Navy and Air Force conduct air to air, air to ground, ship air/surface/submarine warfare and joint training. It is a live training simulation that combines simulated and real targets detected and displayed by platform sensors. A core computer system that performs scenario development, scenario transmission, data logging and post-exercise debrief. Each participant (aircraft, ships, submarines) will have an instrumentation package and data links to inject scenario events into the participant's combat systems through simulation or stimulation.

The Navy BFTT is a virtual training system that uses the actual ship's combat/sensor system as the training system. The BFTT computer on each ship will stimulate the radar, sonar, electronic warfare equipment and communications suite with scenario events controlled by the BFTT computer for single ship training; from another ship for multi-ship training; or from a shore based BFTT computer for fleet or joint virtual training on the synthetic battlefield. This system also provides a debrief for participants to gain maximum benefit from each training scenario.

The Army CCTT is a network of manned simulators providing combined arms and collective training using force-on-force free-play simulation on an electronic battlefield. The manned simulators will include the M-1 series tank, M-2/M-3 Bradley fighting vehicles, FIST-V vehicles and dismounted infantry. Fixed and mobile CCTT systems are planned. The JTCTS, BFTT, and CCTT will rely on the distributed interactive simulation (DIS) communications standards for data communications, which are discussed in more detail in Chapter 6.

The PM should aim to maximize the use of simulations between weapon system and training system development. One example of simulators being developed as weapon system trainers serving an additional function for the acquisition program is in the B-2 aircraft program. As part of the Operational Flight Program (OFP) software development process, the B-2 aircraft program used the weapon system trainer as a systems integration lab to compile and check run the software in conjunction with other real and synthetic data. After any debugging, the OFP was returned to the Flight Test Center to be certified for flight.

The above discussion provides the acquisition manager insight into both the present and planned applications of models and simulation to training. In many cases, the models and simulations which support the development of the weapon system can be used to support the training systems, be they system simulators, or distributed training systems combining live, virtual and constructive simulations. Currently, models and simulations for training purposes are often developed separately by another software development activity. The PM should not have to pay for these simulations twice - an integrated M&S plan during the CED phase can help the transition of simulations between the system and its training simulator.

5.3 Summary

This Chapter provided an overview of the use of models and simulations across the acquisition life cycle and in specific acquisition activities. The challenge for PMs in using these models and simulations efficiently is to:

- Integrate the use of M&S within program planning activities and documentation;

- Plan for life cycle application, support and reuse of models and simulations; and

- Integrate M&S across the functional disciplines.

To aid PMs in their planning for the use of models and simulations, Appendix G contains templates covering some of the acquisition activities discussed in this chapter. These templates should be considered as guidelines only; each program must tailor the models and simulations it uses to the specific activities to be accomplished within that program.

ENDNOTES

1. DoDI 5000.2 Part 4, Section B, Par 3.b.

2. DoD 5000.2M Part 4, Section G.

3. Director, Operational Test & Evaluation Policy Letter. (January 24, 1989). *For the Application of Modeling and Simulation in support of Operational Test and Evaluation;* and DoD 5000.2M, Part 7, Par 3.c.(3) and Par 4.d.(3).

4. DoD 5000.2M, Part 4, Section E.

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6

MODELING AND SIMULATION ISSUES

6.1 Introduction

Over the years, a migration has occurred from live toward constructive and virtual models and simulations. With this migration, software has become an ever-increasing part of models and simulations. This chapter discusses certain technical aspects of software development, use and management which play key roles in planning for the use of these models and simulations.

6.2 Credibility of Models and Simulations (or "How can I believe what I'm seeing?")

The last thing a manager wants to do is to take a recommendation up to a decision-maker, be asked, "Why should I believe this analysis?", and not be able to substantiate the credibility of the underlying information. Not only would the manager have wasted valuable time and money, but the credibility of future program actions may have been jeopardized.

By its very nature, a model is an abstraction of the real world. Factors are often not included in a model; based upon an assessment of the relevance of specific factors to the performance of the model. The perceived relevance of a given factor is also balanced against the cost and complexity of including the factor and modeling its effects. As a result, modelers, analysts and users routinely make assumptions about the relevance of specific factors to the performance of the model. This assessment looks at the value that would be added by their inclusion, and the complexity of effort involved in including them. For example, in most simulations, certain human sensory perceptions, such as smell, heat and cold are omitted, as being either analytically irrelevant or not cost-effective to model.

Naturally, these assessments are effected by how well the factor and its impact on the environment being modeled are understood. Early representations of a system are based upon what is known, at that time, of the technology and related phenomenologies. Models evolve in a spiral fashion as knowledge of these aspects is gained.

So, how do we know that we haven't omitted, or overlooked, something important? More importantly, since results of models and simulations are analyzed to support decision-making, how do we convince the decision-maker that the analyses are credible?

Both these concerns are addressed, in part, by ensuring that the modeling and simulation (M&S) supporting any analysis are both complete and correct. To establish this fact, it is imperative that the M&S be subjected to scrutiny.

A M&S must be verified, validated, and accredited (VV&A). This is a continuous process forming an integral part of an M&S' development, use and maintenance. Credible documentation is also a critical ingredient in success of the VV&A process, as is the control of the overall development process.

6.3 Verification, Validation and Accreditation (VV&A)

6.3.1 What is VV&A?

As Figure 6-1 depicts, VV&A of a model or simulation collectively contribute to its credibility. As the figure shows, VV&A involves the M&S developer, the functional expert and the user. Although the definitions are included in the glossary, this is probably a good place for a more focused definition of each term.

6.3.1.1 Verification – *The process of determining that a model implementation accurately represents the developer's conceptual description and specifications.*[1]

Proper conduct of verification answers the question: "Is it what I intended?"

Verification is applied at each stage of the life cycle to ensure that the products of that

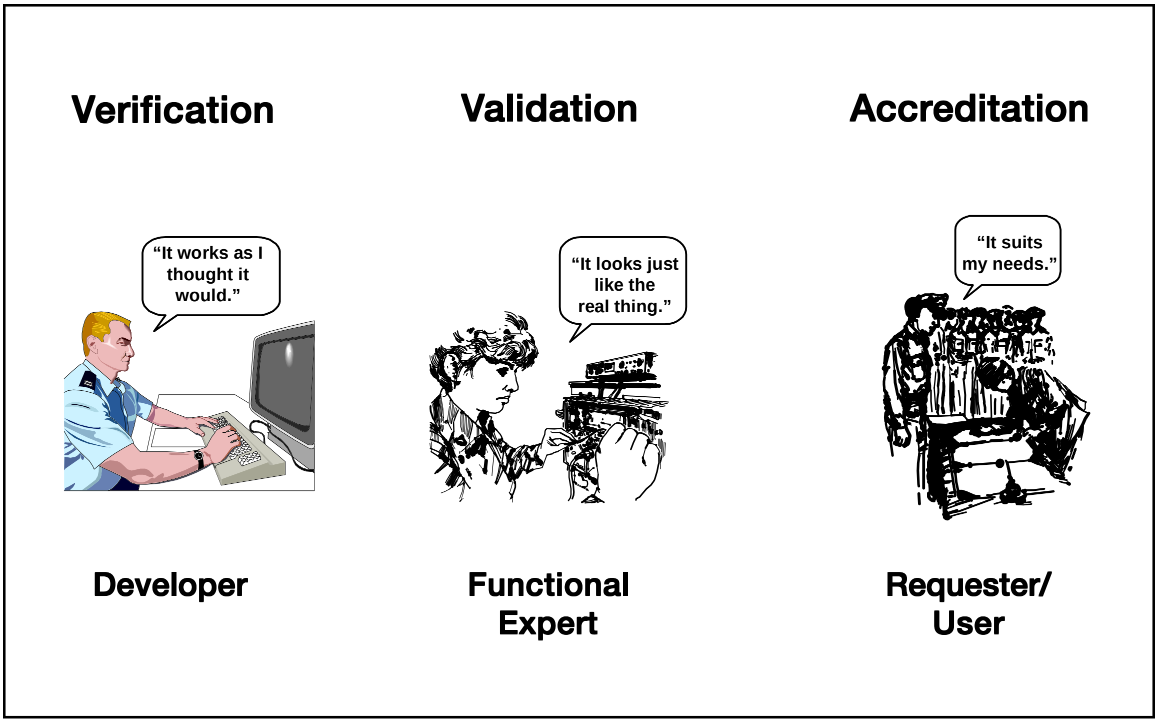

Figure 6-1. Verification, Validation and Accreditation

stage accurately implement the output from the previous stage and contribute to the overall goal. It requires identification and examination of explicit and implicit assumptions and logic flows, and includes appropriate data certification.

6.3.1.2 Validation - *The process of determining (a) the manner and degree to which a model is an accurate representation of the real world from the perspective of the intended use of the model, and (b) the confidence that should be placed on this assessment.*[2]

Proper conduct of validation answers the question: "How well does the model represent what it claims to represent?"

Validation, too, must encompass the entire system, the model, data and even the operators and analysts who will use the model or its results. It is a rigorous process, involving both the structure of a model or simulation; as well as its output. Validation addresses both the fidelity and resolution of a model or simulation. It ensures that all aspects of the real world which should be represented are accounted for in sufficient detail to adequately establish cause-and-effect relationships. Validation provides the foundation for the accreditation process to build upon.

6.3.1.3 Accreditation – *The official certification that a model or simulation is acceptable for use for a specific purpose.*[3]

Proper conduct of the accreditation process answers the question: "Should I endorse this model?"

The agency using the results from a specific application of a M&S (the application sponsor) must establish a set of standards, or acceptability criteria, that a particular M&S must meet to be accredited for a given use. It is important to recognize that any use of the results of a M&S is considered de facto accreditation by the M&S application sponsor. Obviously, the preferred method of accreditation involves a determination, before use, that the M&S is appropriate for that use.

Verification and validation (V&V) consist of varying levels and types of technical evaluations for the model, its development process, as well as the data used to run it.

Accreditation is a management determination, and is largely based upon the technical evidence and audit trail resulting from the V&V process.

6.3.2 Why is VV&A necessary?

The purpose of VV&A is to establish the credibility of a model or simulation as a source of data for analysis.

The output data from models are used to feed analyses supporting decision-making in the DoD acquisition process. These analyses define weapon systems requirements, influence procurement decisions, aid in engineering design, plan and conduct test and evaluation; and establish maintenance levels, sparing, production rates, etc. Furthermore, since output data from one model are often used as input for another, errors become compounded and their sources untraceable.

A 1993 DoD Inspector General (IG) Audit found that as many as 95 percent of models and simulations surveyed (and in use) had not fully incorporated VV&A.[4] The IG's report recommended development of DoD policy, guidance, standards and criteria for VV&A of models and simulations.

At the time of this writing, official DoD policy on VV&A was being developed, as were official Navy, Marine and Air Force policies. Department of The Army Pamphlet (DA PAM) 5-11, *VV&A of Army Models and Simulations*, provides methods, techniques and procedures to conduct VV&A for M&S. However, overall Army policy with respect to development, use and management (including VV&A) of M&S is set forth in Army Regulation (AR) 5-11, *Army Model and Simulation Management Program*.

Some useful information on VV&A is available from the Susceptibility Model Assessment and Range Test (SMART) project sponsored by the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS). Although focused on survivability and vulnerability M&S, the SMART project has developed methodologies for VV&A and conducted research on VV&A procedures throughout DoD that may assist program offices.[5]

6.3.3 Treatment of Legacy Models

Some models for years have been, and still are, workhorses within the various functional communities. These models have usually provided information upon which solid decisions have been based - decisions that have later been justified by actual weapon systems performance in testing or in the field. It would be senseless to preclude the use of these models. Special provisions within most policies must permit grandfathering of models developed prior to the implementation date of formal VV&A policies.

However, even for a legacy model, it is absolutely essential that the accreditation authority, as a minimum, step through the logical thought process that establishes whether or not it is appropriate for use in a certain application.

6.3.4 VV&A: When should it be done?

It is far better to plan and provide resources for VV&A up-front, than to attempt recovery later.

The VV&A of models is neither an afterthought, nor a one-shot affair. An integral part of the model's development process must be VV&A. One benefit of this approach is that it becomes tougher to yield to the temptation of cutting out VV&A, while continuing apace with model development. Otherwise, VV&A is in danger of being viewed as an unnecessary evil, and being cut when resources decline.

As a process, it is also much simpler to conduct V&V as a model is being developed or modified, than to try to re-construct the information required later.

Managers who prefer not to live on the edge, should ensure the V&V status of the models and simulations used to feed the analyses supporting their decisions. The M&S must also be periodically re-accredited (AR 5-11 specifies every five years), to ensure that changes in the world around it have not impacted its credibility. Re-accreditation is not only when a model is changed or used for a new application. This also gives the model manager an opportunity to review recent usage of the model, and make a determination concerning its continued utility to the users. The requirement for periodic re-accreditation also enforces the concept of V&V as continuous processes through the life cycle of an M&S.

Acquisition managers must understand that the emphasis on VV&A is increasing. Data used in decision-making must be defensible.

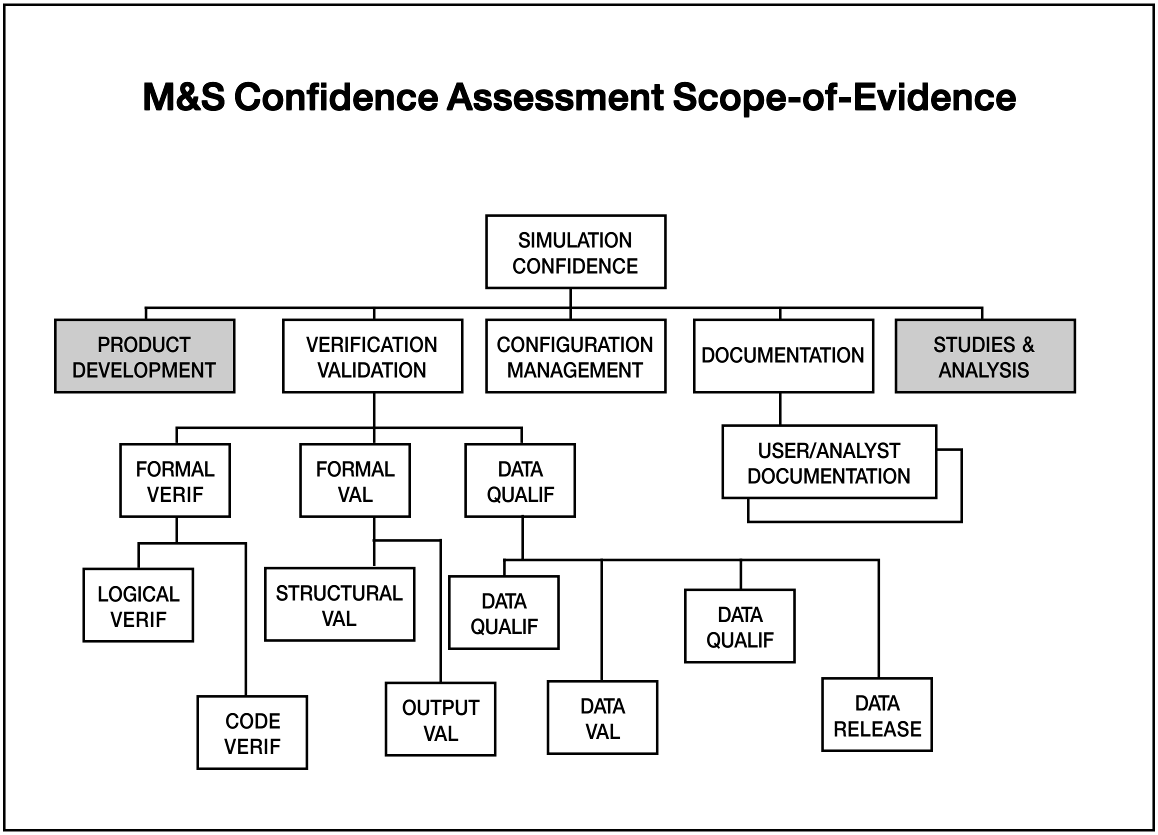

Figure 6-2. M&S Confidence Assessment Scope-of-Evidence

It is a lot easier to challenge the credibility of analyses on the basis of the VV&A status of underlying M&S; rather than to challenge the analyses themselves.

6.3.5 VV&A: Getting it done.

The thrust of VV&A is to establish a degree of confidence in the analyses resulting from the use of an M&S. The scope of technical evidence that must be presented, before expecting a management decision with respect to the credibility of an M&S as a tool, is depicted in Figure 6-2.[6]

Acquisition managers who require development of M&S will be well-advised to ensure that the following four steps are part of the process.

1. Contracts call out the appropriate V&V tasks and criteria.

2. Resources to accomplish the required V&V activities (in-house and contractually) are provided.

3. Data are collected at appropriate points for validation, and that the resources required for test activities are provided.

4. Program schedules allow for the performance of V&V tasks required, including the administrative processing requirements to obtain formal sign-off by the accreditation authority.

6.3.6 Who's Responsible for VV&A?

Sponsor, developer, requester or user. Whether the developer or the sponsor, participation in the process is critical. Everyone has a vested interest in ensuring that credible and supportable decisions result from the analyses fed by the use of a model.

Model developers are most familiar with the model's construction, and are normally best equipped to verify that it has been built the way it was intended. This does *not* negate the requirement for independent verification of the design.

Likewise, functional experts are normally the best equipped to determine whether the model portrays the real world accurately enough. However, here too, an independent validation is required.

Accreditation is basically a matter of acceptance. It answers the question, "Am I going to accept the output of the model?" This is the model user's decision, since it is normally this person who has to defend any recommendation resulting from analyses of the model's output. It is for this reason that the model sponsor/requester/user remains responsible for ensuring that V&V has been performed on the model or simulation. Certainly, one way to accomplish this is to include a requirement for documentation of V&V activities and stipulate acceptability criteria in the Request For Proposal (RFP) and Statement of Work (SOW).

When designing the VV&A plan to gather relevant information to support the accreditation, the question of "How the model(s) will integrate" must be considered.

6.4 Integration

This guide's focus, with regard to integration, principally refers to the extent to which models and simulations are able to cross the barriers between the various functional communities. To effectively support weapon systems acquisition, models must be able to support the implementation of Integrated Product and Process Development (IPPD). Their principal contribution is in improving the cross-functional communications among members of Integrated Product Teams (IPT).

Existing models and simulations used in support of acquisition are mostly of the type that support analyses within the individual major functional areas; concepts and requirements development; design and engineering; logistics, manufacturing and production; test and evaluation; training; and program management.

There are distinct cases of limited cross-functionality between selected areas. However, for the most part, the use of models and simulations appear to be functionally stovepiped. An acquisition environment supporting increased integration among functional areas is needed to break out of the stovepipes. This is an envisioned infrastructure that would support the information needs of users, developers and decision-makers to perform integrated cross-functional analyses throughout the acquisition process.

As an objective, it is not enough for IPT members to be able to just accept the validity of output from models in other functional disciplines—they must be able to use the output to assess the cross-functional implications.

The Director of Defense Research and Engineering's (DDR&E) Acquisition Task

Force on Modeling and Simulation (ATFM&S) formed an IPT Focus Group to:

• Identify needs for models and simulations and related tools that support IPTs in an integrated acquisition environment; and

• Develop technology and non-technology recommendations that meet those needs.

The final report of the ATFM&S expresses the need to develop links between various types of design and engineering models and simulations. Some of the other key acquisition functional areas need to:

• Evaluate performance of alternative designs in combat environments;

• Assess logistics impact of alternative designs;

• Evaluate manufacturing and producibility implications of alternative designs; and

• Evaluate cost, schedule and performance impacts of alternative designs.

The creation of such linkages permits the evaluation of alternative weapon system designs on the basis of the implications across other critical functional areas - in effect providing the means for moving toward a broader concurrent engineering framework. Figure 6-3 depicts the concept of increasing cross-functional integration of acquisition M&S.

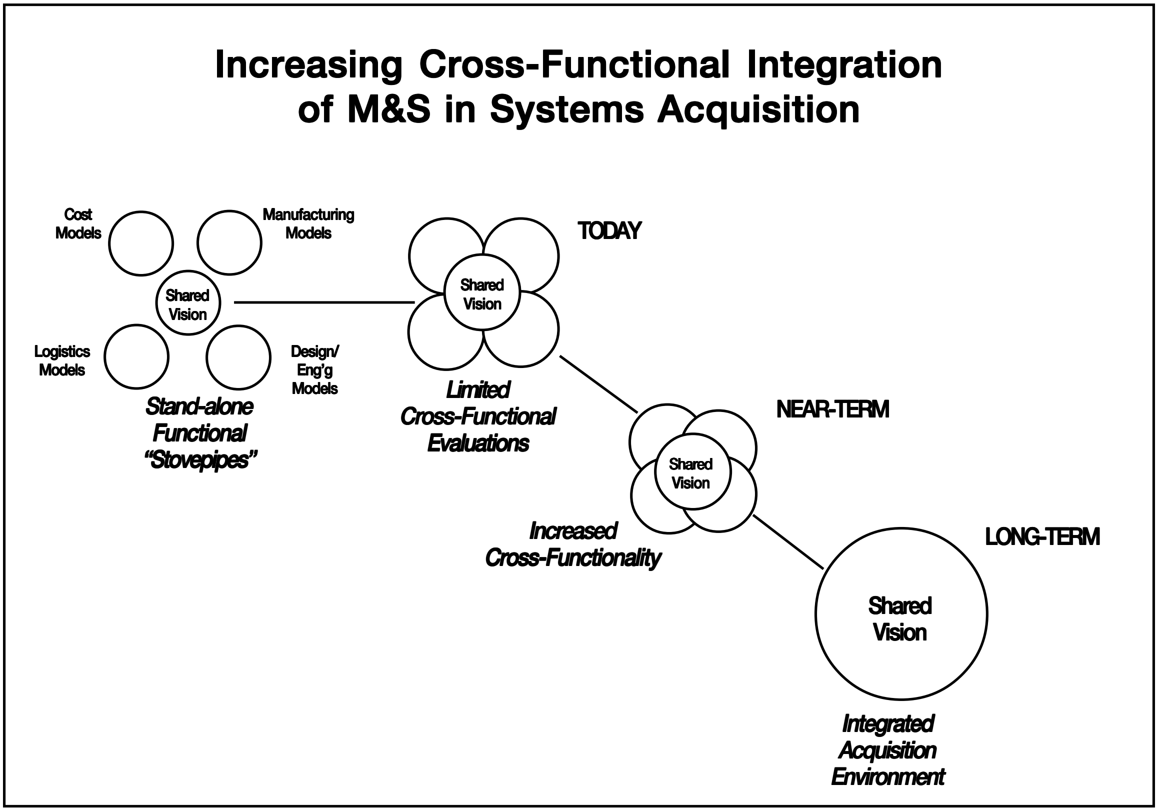

Figure 6-3. Increasing Cross-Functional Integration of M&S in Systems Acquisition

With increasing cross-functionality, comes the need for an increasing commitment to a shared vision. Besides the organizational structure, such a shared vision would also need a commitment to the use of standards, when appropriate. Models supporting the various acquisition functions would need to be able to interact with each other, sharing data and information which will, in effect, allow them a common view of the same electronic space.

6.5 Advanced Distributed Simulation (ADS)

A significant emerging capability of real-time simulation is the ability to synthetically create large environments within which large numbers of subjects can interact. These virtual worlds are made possible by electronically linking individual simulations such that they cooperate in a shared representation of space. Termed ADS, the movement to create these virtual worlds is being driven by DoD's attempts to harness the potential opportunities resulting from the explosive growth in information processing technology.

The capability demonstrated by ADS is the type required to truly integrate the various functional aspects of weapon system acquisition. The Defense Science Board has studied the potential impact of ADS on prototyping, and determined that this technology can provide the means to "transform the acquisition system from within."[7]

The concept of ADS carries with it two distinct characteristics. The first is that of physical separation; the second is that of electronic integration, i.e. two or more physically separate, and separated, models and simulations interacting with each other because they share a common view of their electronic environment. The output resulting from the execution of each model is seen, interpreted and acted upon by the other(s) in real-time.

The Distributed Interactive Simulation (DIS) environment is an infrastructure which implements the concept of ADS. In the current DIS concept, the world is modeled as a set of entities that interact with each other by events that they cause. Whenever the state of an entity changes, such changes are broadcast over the communications media, seen by all other entities, ignored by some and effect others: possibly causing them to respond, resulting in further interaction between the entities within the models.

A key task of the DIS community in defining and providing the infrastructure required to combine individual simulations into a seamless virtual world is the establishment of a series of standards in the areas of:

- Interface definition
- Communication
- Representation of the environment
- Management
- Security
- Field instrumentation
- Performance measurement

The initial focus of applying ADS has been on training. In-roads are being made in its use for evaluating new concepts in combined arms doctrine, tactics, and to some extent, joint interoperability. To fulfill the vision of broader military applications will require its extension into test and evaluation; mission rehearsal; and research, development and acquisition (RD&A).

The highest potential pay-off, at present, appears to be in several areas of RD&A.

- Assisting in defining requirements for new battlefield systems, thereby reducing the risks of embarking on lengthy and expensive development programs.

• Playing a key role in conducting certain aspects of early user testing and evaluation, as a weapon system design matures. Frequent involvement by the user in a synthetic environment will make the design-test-fix cycle faster. The use of simulation during design, testing and prototyping a design fix (or model-test-model) can ensure an acceptable fix before major investment of funds in an actual build.

• Conducting portions of weapon systems' developmental and operational testing and evaluation (DT&E and OT&E) in a synthetic environment. As noted in Chapter 5, several aspects of DT&E already involve the use of simulation. Although models and simulations have been used fairly extensively in support of OT&E, extending the use of ADS to conduct OT&E is relatively fertile ground. DoD seeks to apply a higher standard of acceptability for models or simulations used in support of OT&E, requiring that "special care is necessary to ensure they are credible".[8] Understandably so, since OT&E is often the last line of defense against carrying risks into the next phase of acquisition. However, with VV&A for distributed M&S being more complicated than for monolithic or stand-alone M&S, establishing sufficient credibility for their use in support of OT&E, will carry some special challenges.

Several technical issues still limit the full extension of ADS into the acquisition domain.

• Program managers (PMs) intending to construct models for use in the DIS domain should familiarize themselves with the issues[9], and track their resolution over time.

• PMs should recognize the importance of being in control of the manner in which their system is represented and used on the synthetic battlefield.

• In the longer term, PMs electing not to build DIS-compliant simulations, will run the risk of one being developed and used outside their control.

• One of the critical technical issues involved in extending the use of ADS into acquisition remains that of establishing standards; permitting the models and simulations to interact.

6.6 Standards for the Modeling and Simulation Environments

Charles D. Sullivan defines a standard as "a category of documents whose function is to control some aspect of human endeavor."[10] Standards are established to overlay a certain discipline on a process or product. Unless such discipline is established with specific purposes in mind, control ends up being established for no reason other than the exercise of power. The bad press DoD's application of standards has had in recent years is not the result of the existence of these standards; rather, it is the sometimes blind imposition or implementation of them.

The objective behind the creation of a standard must be considered from two, often very different, perspectives: "Why create a standard?" and "Why use one?" The clearer the objectives behind the creation of a standard, the more likely it is that the standard will be used by those for whom it is intended.

If there were ever a discipline that could gain significantly from implementation and enforcement of a reasoned approach to establishment and adoption of standards, it is that of the development of models.

Currently there is no universal standard within DoD for models and simulations. This appears to be a conscious decision to force an evolution toward a set of broad standards that could serve wider needs within the acquisition community. There are standards development efforts underway within the various functional communities and application domains. Over time, the need to efficiently share information between functional areas will provide a forcing function to evolve a set of common standards. These need to be broad enough to encompass the needs of each community without requiring unacceptable compromises, yet definitive enough to permit cross-functional interaction.

Even a model developed to comply with a certain set of standards is at risk of drifting over time, as its configuration changes. To ensure the continuing ability of a model to serve the purpose it was built for, its credibility will have to be maintained over its life cycle through a planned maintenance and re-accreditation process.

6.7 Maintaining Credibility of M&S

Having established a model's suitability for use, whether for a class of applications or for a specific one, a rigorous effort is required to ensure that it remains credible.

Since a portion of most models or simulations is software, loss of configuration control can occur insidiously, over time, and invisibly. An Army Audit Agency Advisory Report mentions that, over a period of two years, "one model was modified 623 times (including 9 major changes) without revalidation".[11]

Managing and controlling a model's configuration becomes crucial in maintaining it as a credible tool to support analyses.

6.7.1 Configuration Management (CM)

During the process of developing DA PAM 5-11, *VV&A of Army Models and Simulations*, the writers concluded that a strong CM plan is one of the critical ingredients in ensuring the continued credibility of models and simulations. The CM plan for a model must ensure controls for the model itself, its development process and the input data.

Configuration management is defined[12] as a discipline applying technical and administrative direction over the life cycle of an item to:

- Identify and document the functional and physical characteristics of the item and its major parts;

- Control changes to these parts and to their related documentation;

- Establish a process for maintaining status of proposed changes, implementation status of approved changes, etc.; and

- Establish a process for conduct of audits to verify conformance of the item's (and its major parts') design and performance with requirements documentation.

This general definition covers any configuration item within a system, be it hardware, software or firmware.

There are several reasons why a good CM is an especially important activity for models and simulations.

1. *Facilitates repeatability:* Maintaining a record copy of an M&S used in providing information to support an analysis, along with its associated input data, provides an M&S user the ability to reconstruct the analysis at a later date.

2. *Enables traceability:* Maintaining a clear audit trail of changes to a model and input data provides a mechanism for correlating each change to the circumstance(s) generating the requirement. This allows proper analysis of the cause-and-effect relationships among a series of experiments.

3. *Maintains credibility:* This is probably the strongest argument for a rigorous CM program, and is directly linked to the previous two items. A well constructed and implemented CM plan for a model will significantly reduce the risk of its data output being misused in an analysis.

4. *Maintains interfaces:* Integrated, interoperable and interactive models and simulations are becoming more important to efficient conduct of DoD's business. It is critical to identify and control any changes which may disrupt this interoperability.

Three elements are considered essential for adequate CM:

1. A CM policy establishing the administrative processes for approving and documenting changes to the model or simulation;

2. A CM plan describing how changes to the existing configuration will be accomplished; and

3. A CM board or official with authority to approve proposed changes to the currently approved configuration.

Some managers have encountered problems following release of a model and recommend more stringent measures to protect the configuration. The following guidelines have proven effective for several model managers.

- Maintaining a baseline copy of each version

- Tight control of changes by users (implementing a policy of not releasing source code)

- Execution of various forms of agreements with model users

- Formation of user's groups that are particularly useful in addressing CM issues pertaining to:

  — Documenting changes made (or suggested) by users other than the model manager;

  — Evaluation of proposed changes; and

  — Suggesting and developing methodologies for V&V of changes.

Across the board, one of the most useful mechanisms for PMs appears to be maintenance of a record copy (baseline version plus changes) of each model or simulation used, *along with the validated data for that version*. This is of tremendous benefit to the model user since analyses supporting a decision must often be traceable to the specific configuration of a model exercised: to provide information for the analyses and the data used in its execution.

Any CM can be resource intensive. Managers are advised to assess any potential impacts. The PMs need to ask such questions as:

- What resources are going to be required to implement an effective CM program?

- Do program management office personnel have the required training (technical and other) to oversee CM activities, facilitate user group meetings, etc.?

• If the model manager maintains total control of source code, does the office have the resources to be the only one making changes to the model? If not, will users be willing to provide reimbursement for the effort(s)?

If the objective is to get others to use a model because of its ability to improve a process or product, it does not make much sense to implement inordinately stringent controls. However, there may also be valid concerns about proliferation of unauthorized versions, loss of credibility in the model as a tool, etc. The structure of the CM process should implement a level of control needed, without making it unnecessarily hard for potential users to get the model and use it.

A good CM plan is critical to maintain the credibility of a model, ensure its continued compliance with standards to which it was designed and ensure its overall utility to the program. Investment in good M&S CM may minimize future problems with credibility.

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7

MANAGEMENT CONSIDERATIONS IN MODELING AND SIMULATION

7.1 Introduction

This chapter will consolidate some of the management considerations involved in the use of models and simulations in systems acquisition. It will also provide a notional process to plan the modeling and simulation (M&S) effort for a program.

7.2 Survey of ACAT I & II PMOs

In September 1993, the Defense Modeling and Simulation Office (DMSO) Acquisition Task Force on Modeling and Simulation (ATFM&S) initiated a survey of DoD ACAT I & II Program Management Offices (PMOs).

7.2.1 Purpose

The purpose of the survey was threefold:

1. Gain information on how the armed services were currently using M&S;

2. Determine the degree of existing cross-functionality in current models and simulations; and

3. Identify improvements the DoD acquisition community felt were most needed to provide better support to acquisition programs in the future.

7.2.2 Survey Method

The survey was sent to selected program offices across the Army, Navy, Marine Corps and Air Force. Selected survey responses were followed-up through site visits and interviews (one-on-one and group).

7.2.3 Summary of Survey Results

The results of the 56 responses provide some valuable insights into M&S use. Response information pertaining to how PMOs are currently using M&S is summarized in Figure 7-1;1 and further explained below.

7.2.3.1 Modeling and Simulation Use

A majority of respondents indicated moderate-to-extensive use of models and simulations to support acquisition decision processes. While the largest number of uses were in the threat, requirements, cost and testing areas; the largest single use by pro-

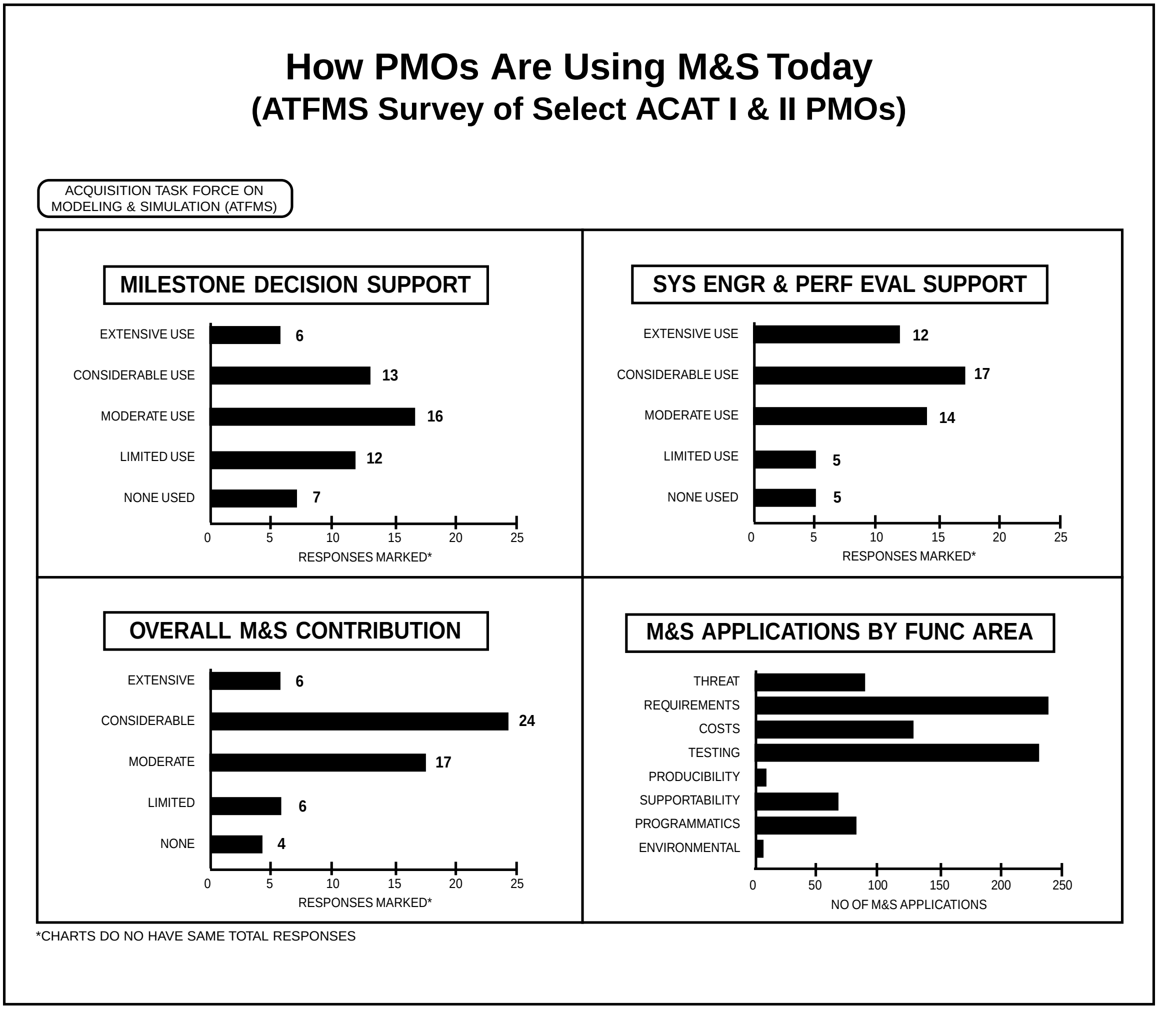

Figure 7-1. How Program Management Offices are Currently Using Modeling & Simulation

gram managers (PMs) was in the area of systems engineering and performance evaluation. Overall, the survey confirmed that models and simulations were being used across a variety of functional areas.

7.2.3.2 Modeling & Simulation Needs

The survey results, with respect to expressed needs of PMOs, are summarized in Figure 7-2.2 Some of the key issues recommended for addressal were to provide adequate resources for M&S efforts, consistency in cost models, user-friendly models and simulations, and more and better information (training and reference material) on the use of models and simulations.

With respect to what capabilities the PMs would like to see improved, the majority of responses were in the areas of: improved scheduling models; improved cost and operational effectiveness analysis (COEA) and life-cycle cost (LCC) tools; improved interoperability with other models; and improved program specific models.

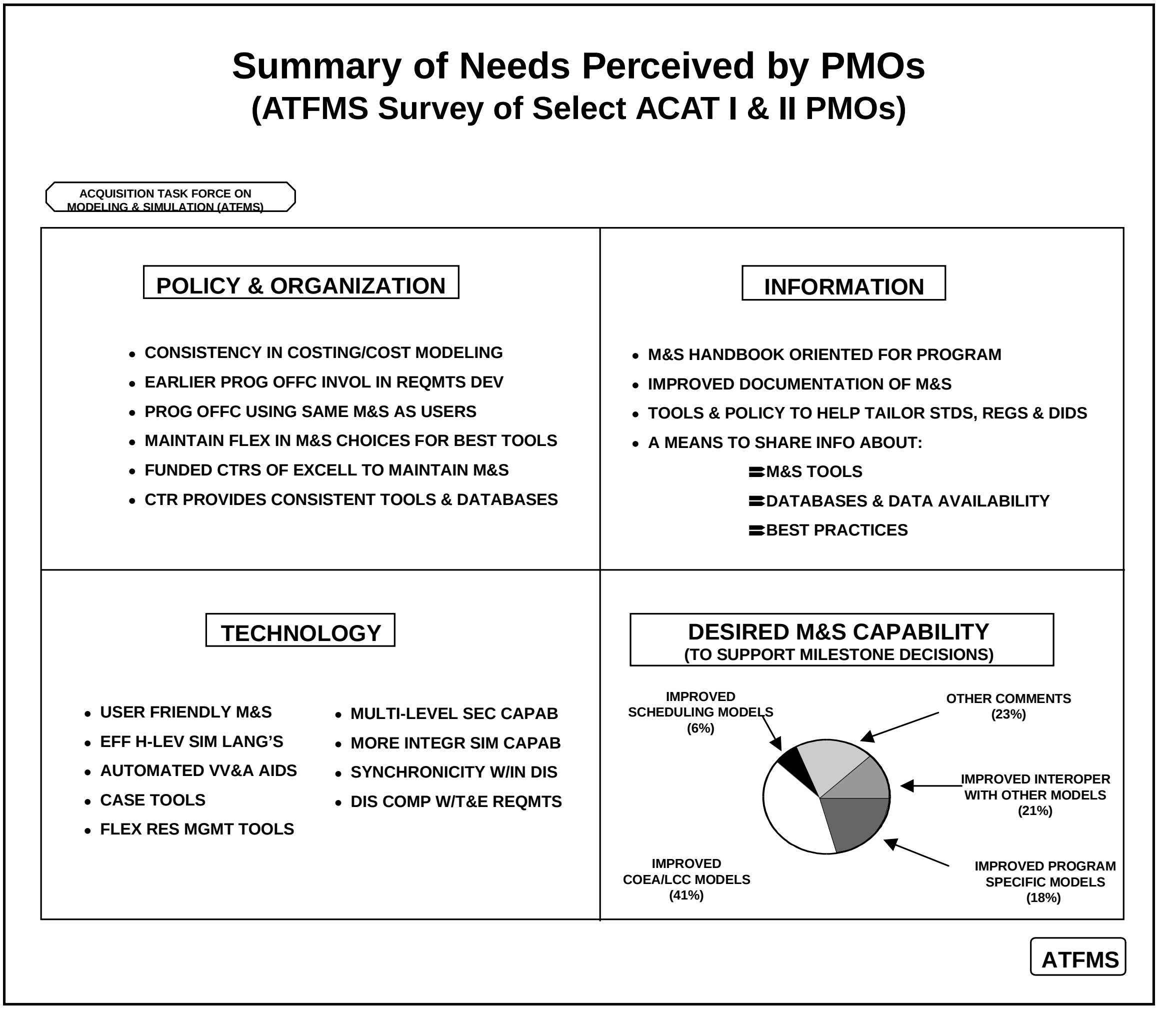

Figure 7-2. Summary of Modeling and Simulation Needs Perceived by PMOs

7.2.3.3 Centralized vs Decentralized Management

The survey indicated a predominance of decentralized management, wherein the model user(s) managed the development and use of models they needed for their particular functional area. However, the survey indicated a strong correlation between the type of management of M&S efforts and perceived overall contribution from their use.

The PMOs reporting centralized management perceived the overall contribution as considerable to extensive. This relationship is strong enough to warrant consideration of centrally managing the M&S effort within the PMO. Each PM must make a conscious choice in the type of M&S management to implement. Factors to consider in determining whether to centralize management under a simulation manager include: availability of an individual with the requisite breadth of knowledge and training; the PM's management style; the PM's organizational structure; and the scope of the effort.

The scope of the M&S effort within a PMO will be determined by factors such as the number of models and simulations developed, used and maintained; the purposes for which they are employed; and their complexity and sophistication. A universal model (one that models every aspect of the program) for a given program, is panacea. A given program will normally require the use of several models and simulations, desirably using common data bases. Their management is not trivial.

7.3 Planning the Modeling and Simulation Effort

A manager, when initiating the M&S planning effort, must take a bottoms-up approach. The tool has to fit the need, requiring managers to start determining their M&S requirements based upon what they are trying to accomplish.

The decision to employ models and simulations, as well as the subsequent decision(s) to use or modify an existing model, or create a new model, will depend on the circumstances and specifics of a given program. The questions which follow are not offered to trivialize the process with a cookbook solution.

The templates in Appendix G provide a baseline from which PMs can develop questions reflecting their programs. The supporting functional managers can then step through the questions below to fill in the blanks.

- What am I trying to achieve? What's the objective? What question(s) am I trying to answer?

- What analyses will have to be conducted? When will the results be needed? How long will the analyses take? Who will do them?

- What information is required to support the analyses? How accurate does the information have to be?

- What's the most efficient way to get the information? Are several excursions (or iterations) going to be required? Is it a one-time requirement, or will this be an on-going requirement? Do I need a model to provide the information?

- Can any existing models or simulations provide the information I need? What is the verification, validation and accreditation (VV&A) status? Are they accredited for my class of system? Will they need modification? What's the extent of modification? Can the model owner(s) do the modification in-house? Can I? Any proprietary issues that may lock me in to a sole source?

- What data are required by these model(s)? Where and how can the data be obtained?

- What resources (funds, people, time, test articles, hardware, software, range facilities, documentation) will I need to:

  — build or modify the model(s)?

  — conduct VV&A on the model(s) or modification?

  — implement configuration management (CM)?

  — obtain and validate the data?

  — run the model(s)?

  — analyze the output?

— ensure that the model(s) are maintained to accurately represent my system or program?

— transition the models and simulations to a supporting activity for maintenance upon dissolution of my PMO? Does "operation and support" funding provide for model(s) maintenance after transition?

• Does the system design accommodate plans for hardware/software-in-the-loop (HW/SWIL) with regards to test and instrumentation ports, etc. What do I need to populate my test bed(s) or simulation facility(ies)?

Are my models and simulations consistent and integrated with the rest of my program? Are they reflected as tools contributing to requirements verification in a requirements correlation matrix (RCM)? Are their characteristics consistent with the COEA, test and evaluation master plan (TEMP), operational requirements document (ORD), and acquisition program baseline (APB) with respect to measures of outcome, effectiveness and performance (MOOs, MOEs, and MOPs)?

Once managers have completed this thought process, all the ingredients of a plan are in place.

• The tasks, functions or decisions to be supported by M&S

• The specific M&S tools required

• When they are needed

• How the M&S are going to be acquired

• The resources required to acquire and manage the M&S

7.3.1 The Simulation Support Plan

In an attempt to ensure early consideration and planning the use of M&S in major programs, the Army has mandated development of a Simulation Support Plan (SSP) for all ACAT I and ACAT II programs, as well as for Advanced Technology Demonstrations (ATDs). The SSP forces PMs to view the entire program in the context of the decisions to be made, timing, and impact (relative importance). It forces managers to consider information needs in light of the decisions to be supported, and assess the applicability of models and simulation to providing the information. Figure 7-3 is a proposed outline for an SSP.

PMs must consider the resources required to build the program, which includes the SSP. The SSP is considered an evolutionary document, and is supposed to be refined, through periodic review, as the program progresses. Like other components of an acquisition program, the M&S requirements will coalesce and get more detailed over time.

It is not the SSP itself, but the "journey" through the process of identifying the program's M&S needs that is more valuable. Creating a bureaucracy that simply requires "another plan", would be counter-productive.

One of the initial challenges a manager will face is in trying to identify existing resources that could be used (either as is or with modifications) to address the M&S needs. A plethora of models and simulations have already been developed and are in various stages of accreditation for different pur-

Outline for a Simulation Support Plan

I. Purpose
- Brief statement as to why plan is required
  - Focus on the use of M&S in the program

II. Executive Summary
- Summary narrative of Section V.

III. System Description
- Brief summary of weapon system

IV. Program Acquisition Strategy
- Brief synopsis of system acquisition strategy
- Overview of M&S acquisition strategy
  - Include role of weapon system M&S in the distributed environment

V. Simulation Approach/Strategy and Rationale
- What M&S is being done, and why

A. M&S used to date
- Discuss all previous M&S used to support the program
  - Name/Type of M&S (Live, Constructive or Virtual)
  - V&V performed on M&S - Accreditation status of M&S
  - To what phase/milestone was M&S applied
  - Issues addressed and results
  - Include M&S supporting:
    — Mission area analyses
    — Operational analyses
    — Requirements trade-offs
    — Conceptual design studies
    — Systems engineering trade-offs
    — Cost and operation effectiveness analyses
    — Logistics analyses
    — Test and evaluation
    — Training

B. Future Simulation
- Include on-going M&S
- All planned M&S for future milestones
- How planned M&S will support future milestones
- How planned M&S supports the Service's vision for M&S

(continued)

Figure 7-3. Outline for a Simulation Support Plan (SSP)

Outline for a Simulation Support Plan (continued)

VI. Related Simulation Activities
Include
- **Other M&S activities the system relies upon**
- **Other systems that rely upon this system's M&S tools**
- **All other related M&S that affect this system**

VII. Management
- **Provide wiring diagram of PMO**
- **Show simulation manager (if assigned) in diagram**
- **Describe how simulation manager interacts with acquisition community**

VIII. Facilities/Equipment Requirements
Describe facility requirements for all M&S
- **All facilities, hardware, software, data, etc.**
  - **Provided by PM, other Gov't activities, contractor(s)**
  - **Identify who will provide**
  - **Identify schedule requirements and availability of items to support schedule**

***Ensure government ownership of equipment (including simulators, hardware, software, data, etc.) critical for cost effective government manageme*nt of M&S**

IX. Funding
- **Outline all expected expenditures to support M&S program**
- **Include funded and unfunded**
- **Designate type of funding (by Program Elements (PE), project, etc.)**

X. Remarks/Supplemental Information
- **Any comments or related information**

XI. Appendices
- **Program Schedules**
- **M&S Schedules**
- **Acronyms and abbreviations**
- **Related standards**
- **Related government documents**

Figure 7-3(Cont'd). Outline for a Simulation Support Plan (SSP) poses. However, the PM must know how to get the information needed to make a decision as to whether one or more of these could satisfy an M&S need.

7.3.2 Models and Simulations Catalogs

The discipline of modeling has been likened to a cottage industry, with a proliferation of models among the various Services, and even within individual services. A March 1993 DoD Inspector General's (IG's) audit of selected models and simulations and their developing and using activities concluded that "Model and simulation projects are being procured and developed within the DoD without adequate coordination and control", and that "This has resulted in redundant models/simulations and a proliferation of system architectures and libraries".[3]

The IG reports: results can be contributed to lack of communication. One Service not being aware of what models the others have. This can also be extended to the Services lack of awareness of the applicability, modifiability, portability, or V&V status of those models within their respective Service. This issue is being addressed, to some extent, by the creation of models and simulations catalogs by each Service and the Joint Staff. These efforts, while valuable, have not resulted in complete listings. Many model users are unaware of the existence of these catalogs; many others, though aware of their existence, may not have submitted their models for inclusion.

Appendices A through E include reference to the service catalog(s) and information on how to gain access to the information. Appendix F includes a partial list of other sources of information. On-line access to many catalogs is also provided by the Service sponsor, and by the DMSO, through their Modeling and Simulation Information System (MSIS).

Model developers and users should use the catalogs as a starting point while preparing an SSP. However, they are not all-inclusive; so, even if they do not list a model that satisfies the need, points of contact (POCs) for similar models may be able to provide some additional leads.

The PMOs often do not have resident experts to answer the questions required to plan their use of M&S. Often times DoD PMOs must turn to contractors, consultants or other agencies for assistance in determining the M&S needs for the program, as well as developing the M&S tools.

7.3.3 Selecting a Modeling and Simulations Developer

This section will assist the PM in identifying or selecting a contractor to assist in the M&S effort.

The PM must identify a M&S developer. This could be a government agency, an independent contractor or the prime system contractor. Obviously, the developer must understand M&S and the PM's unique requirements. A list of questions that may help the PM select a developer is provided by Van B. Norman.[4] This list is based upon twenty-years of building simulation models, and hiring and managing simulation consultants.

In DoD's case, these questions can form the basis for part(s) of a Request For Proposal (RFP), as well as provide ingredients for establishing Source Selection Criteria.

The specific questions, and the level to which they will have to be pursued, will depend upon certain factors within the program acquisition strategy. Among these are factors such as: whether the main effort and the simulation effort are under a common contract; who is integrating the simulation effort; whether the system and simulation development efforts are complementary, with each leveraging off the other; or whether they are independent.

a. *What is the contractor's experience with this type of system? What is the contractor's track record?*

A contractor's experience with similar systems is important, since it normally generates efficiency, but it is not essential. If a specific contractor has an unproven record, a software capability evaluation5 may provide some insight into their ability to take on a complex software modeling effort. This is particularly true if the M&S development is a parallel effort to the system development. The evaluation augments the acquisition process by determining a contractor's strengths and weaknesses with respect to a maturity model. It establishes a method for comparing a contractor's "software capability" against a standard set of criteria as a source selection criterion.

b. *How will the contractor approach the construction of the model? What simulation software will be used?*

Maybe there is a requirement for a specific software tool. Ada may not be the most appropriate—if possible, choose a simulation tool that is widely used and will be around for a few years.

c. *Will the contractor produce a written specification describing the system to be modeled, including all assumptions and questions to be answered? Are you going to be providing the contractor a specification?*

In any case, the specification is necessary to ensure that everyone is working toward the same goal.

d. *What questions about the system cannot be answered from use of the model?*

Models need to be constructed with certain questions in mind. An understanding of what the model will not answer is crucial to prevent misunderstanding between the project office and the developing contractor. Another reason why the model specification is so important.

e. *What is the development schedule?*

The model or simulation supports certain information needs of the project office. Unless this information is timely, it could be worthless. The contractor's prior record with respect to ability to deliver on schedule should be a important criterion in selection.

f. *How did the contractor arrive at the cost estimate for the projects?*

Regardless of whether the contractor is working on a cost-plus or fixed price basis, the contractor must understand the scope of work and schedule to develop a credible cost estimate.

g. *How do I determine value for cost?*

Norman likens simulation consulting to brain surgery - "if you want the lowest priced surgeon opening your head, then good luck",6 he says. He emphasizes the need to know the experience, expertise, and record of each candidate contractor, and to balance these against the price being charged to determine value.

h. *What data are required for the model?*

Norman contends that most contractors won't know your business well enough to collect the required data. The government will often need to provide the data. Fortunately, sources of valid data exist within each Service and DoD. Each Service's M&S office can provide authoritative sources of data. Despite the unique needs of each Service, a common dictionary of data is required among the Services.

i. *Who will collect the data? When will it be needed? What format will it be needed? Who will certify the data?*

Crucial questions, if the government is going to be on the hook to provide these to the modeler. In fact, any potential disconnect between the contractor's requirements for data and the government's ability to provide it must be worked out early. The PMs must also understand the resource implications of data collection.

j. *What parts of the system will be detailed and what parts will be simplified?*

Again, an issue that the contractor must address in the proposed specification.

k. *What types of model experiments will be run?*

As the model is built, experimentation provides answers. If the modeler knows what types of experiments are contemplated, the model can be built to make the experiments easier.

l. *How much time will be allowed for experimentation?*

The user's understanding of the system may change after reviewing experiment results, and the scope of work may be impacted. A well structured CM process will make this less painful.

m. *How will you be assured the model is "correct"?*

The government must be an active player in the V&V process. The PMs must also be mindful of the accreditation authority's requirements from the start - the requirements must be built into the contract.

n. *What is the schedule for periodic model review meetings?*

This is a crucial management mechanism for ensuring that incremental model development is on track from cost, schedule and performance viewpoints.

o. *Can you use the model internally after the contractor is done?*

The model has long term value. The system will probably change over time and the model must be modified. This relates back to the need for CM and the requirement for adequate documentation.

Reusability of software and the increasing move toward reconfigurable simulators and simulations make this even more important. Also, the government's aversion to locking itself into a developer drives the need for the government to identify in the contract all its M&S deliverable requirements, and timing. Inclusion of contractor proprietary material or data, without adequate rights being released to (procured by) the government, could lead to problems.

p. *What could go wrong with this part of the project?*

Monitor the model (or simulation) development effort as it proceeds. Given the criteria for establishment of Work Breakdown Structure (WBS) elements (MIL-STD 881B), and Configuration Items (MIL-STD 973), PMs must:

— Ensure visibility of the M&S efforts at the appropriate level for management and

— Incorporate the development efforts into their risk management program.

q. *What kinds of analyses will the contractor perform, such as confidence interval calculation and design of experiments?*

Whether it is the contractor or someone else who is going to be performing an analysis using the model's output, the analyst's requirements have to be considered in designing the model.

Norman rounds out his suite of questions ensuring that the contractor will assist in gaining management and team support for the model and for its use in support of the analyses at hand. The contractor is, after all, part of the team.

r. *"How will the contractor assist in explaining the benefits and limitations of the model?" "Will the contractor assist in presenting the model results to management (decision makers)?" and "Does the contractor have the capability to provide a video of the model's animation?"*

All of these will go far in gaining and maintaining support for the effort, since they create an understanding of the need for the model and subsequent analyses of its results.

7.4 Models and Simulations as Deliverables

The PM must be aware that some models and simulations will be developed by the prime contractor as a natural by-product of the system design and development process. However, the capabilities and limitations of these models and simulations, with respect to the acquisition process, must be understood. Decisions regarding whether or not to require specific M&S as deliverables, must be made on a case-by-case basis with this understanding.

Contractors may also be reluctant to share key algorithms included in simulations specified for delivery. Based on the program's acquisition strategy, the PM must assess impacts of any restrictions the contractor may include, and determine whether (and how much) it would be worth paying for their removal.

A PM must also recognize that when production is complete and a contract ends, M&S support will still be required for the remainder of the system's life cycle. Models and simulations that were constructed during earlier phases of the acquisition process, and refined as the system evolved, will play a major role in evaluating system modification alternatives.

ENDNOTES

1. "Weapons Systems Acquisition Cycle Improvement (Through Integration of Modeling and Simulation)," Report of the US Army Materiel Command Task Force, June 10, 1994.

2. Ibid.

3. DoD IG Audit Report No. 93-060, "Duplication/ Proliferation of Weapons Systems' Modeling and Simulation Efforts Within DoD", March 1, 1993.

4. Used with permission of Van B. Norman, "Twenty Questions for Your Simulation Consultant", Industrial Engineering, May 1993.

5. *Mission Critical Computer Resources Management.* Section 8.6.3.6. Ft. Belvoir, VA: Defense Systems Management College.

6. Van B.Norman, "Twenty Questions for Your Simulation Consultant", Industrial Engineering, May 1993.

8

MOVEMENT TOWARD A FUTURE STATE OF MODELING AND SIMULATION

8.1 Introduction

This chapter presents the reader with a vision of what the combined technical and management state-of-the-art appear to be converging toward. The chapter also provides some examples of DoD programs: where the use of models and simulations is paying dividends today.

8.2 The Evolution of Modeling and Simulation (M&S) in Acquisition

Technology is rapidly evolving toward, with some contending that it has already arrived at, a state permitting the increasingly sophisticated implementation of integrated product and process teams. Acquisition management will need to evolve in directions that will allow managers to take advantage of this integration.

A migration is occurring from predominant use of live and constructive simulations, to increased interest on the use of virtual simulations. This shift is supported by rapid improvements in the sophistication of information processing and display technologies. However, today's technical and managerial use of M&S in support of systems acquisition is largely characterized by use of these tools in stand-alone and system-specific modes.

Scant information is provided on existing resources, institutional barriers and emergent policy. An interest in increasing communication among functional areas observed throughout the acquisition community is coupled with the continuing revolution in information processing technologies.

This strongly indicates that the future state of M&S in acquisition will consist of environments which seamlessly integrate simulations. Integration will occur among simulations of similar and different classes (live, constructive and virtual) and across levels of the M&S hierarchy (engineering, engagement, mission/battle and theater/campaign); while providing information that will support planning and decision making in all functional areas and at the requisite level of resolution for specific decisions.

8.2.1 Vision for the future state of Modeling and Simulation

John Hartley writes that technical developments and environmental changes "will continue to move the goal posts".[1] More powerful computer-aided design (CAD) workstations, along with distributed systems sharing common object-oriented relational data bases, will permit all departments working on a project access to the same product data. Product data, when used by the manufacturing department, will be suitable for generating machine tool paths and basic dimensions for fixtures or die forms.

Using the same data, logistics engineers would be able to conduct reliability and maintainability analyses, and find the location of key maintenance points such as access plates, sockets, etc.. The same data would be available to cost estimators in such a way that costing could be done easily and fiscal impacts of engineering design changes would become apparent.

Thus, each department would see the same (and latest) data at all times, from concept through final design. Members of the product team, contacted about a proposed change, would be able to run simulations to assess impacts from their department's perspectives and offer alternatives, which again other members of the team could evaluate for impacts.

Hartley also writes about the likelihood that contractors will be brought more closely into the net, relying on the same data base as the customer. He recognizes similar concerns to those voiced by defense contractors; with respect to proprietary nature of selected data and the resultant issues that DoD and contractors wrestle with in the Continuous Acquisition and Life-Cycle Support (CALS) initiative.

A close representation of the future state is provided by the recent development of tools such as the Computer-Aided Three Dimensional Interactive Applications (CATIA) software package. The CATIA is a series of application programs that interact to form a highly integrated design, analysis and manufacturing system.[2] Boeing used CATIA in the highly publicized design of the 777 aircraft, and is currently using the tool in the design of the F-22 aircraft.

8.3 Virtual Prototyping at the US Army Tank Automotive and Armament Research, Development, and Engineering Center (TARDEC)

Engineers at TARDEC are well on their way to designing a limited implementation of the vision for the use of M&S in an integrated acquisition environment.

The TARDEC engineers have developed their virtual prototype process to lend itself to continuous user participation.(Soldiers who will eventually use the system in the field.) This process provides more rapid feedback to the developer (the government-contractor team responsible for developing the system). Using advanced computer simulation enables early evaluation of new vehicle concepts without actually building a physical vehicle. User/developer agreement is maintained throughout the process depicted in Figure 8-1.

The steps in the process are explained below.

Step 1: *Concepts* – Solid models of alternative materiel concepts, such as external

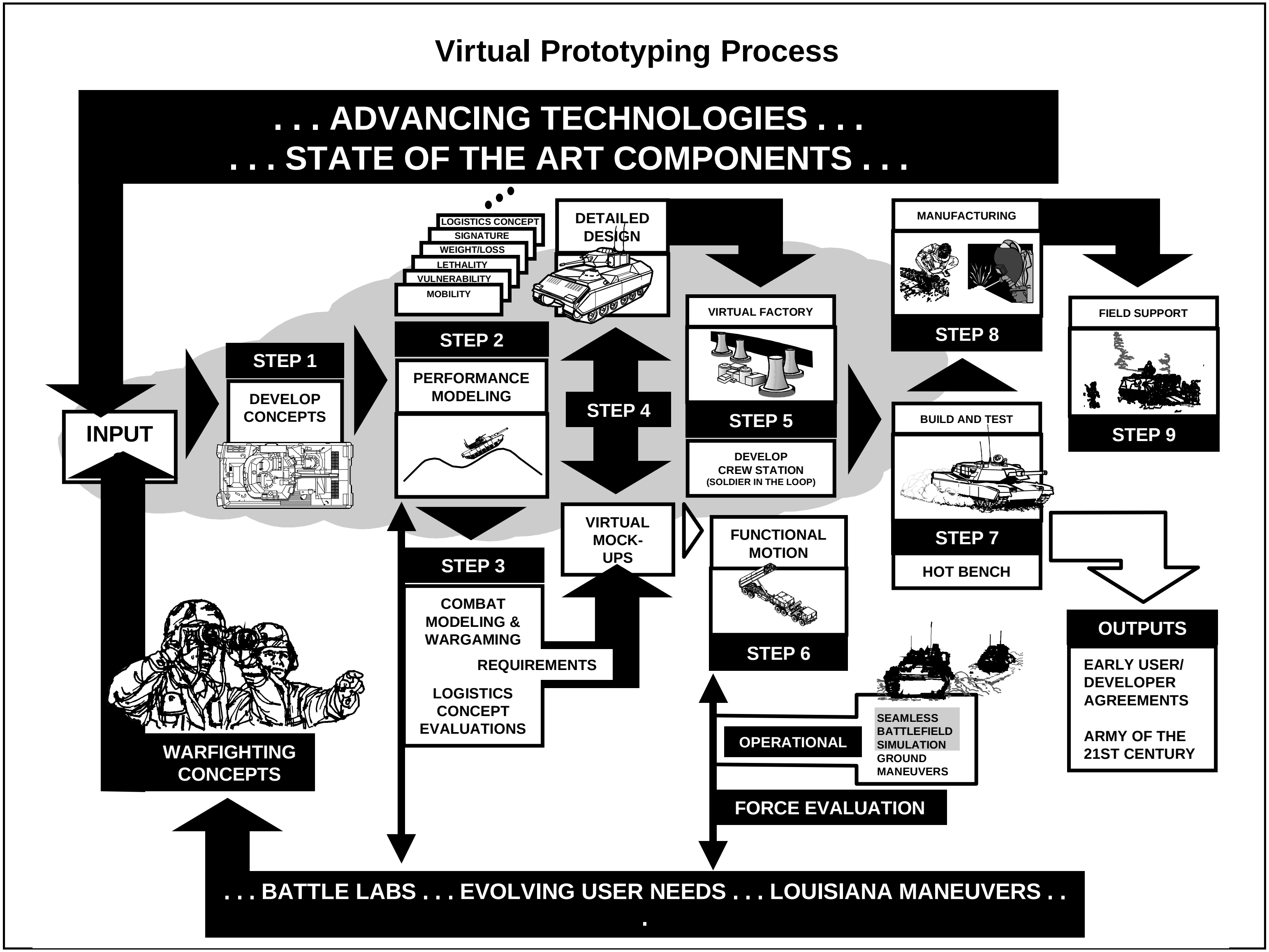

Figure 8-1. Virtual Prototyping Process

The Tracked Vehicle Workstation:
Expanding Vehicle Simulation's Role in the Vehicle Development Process

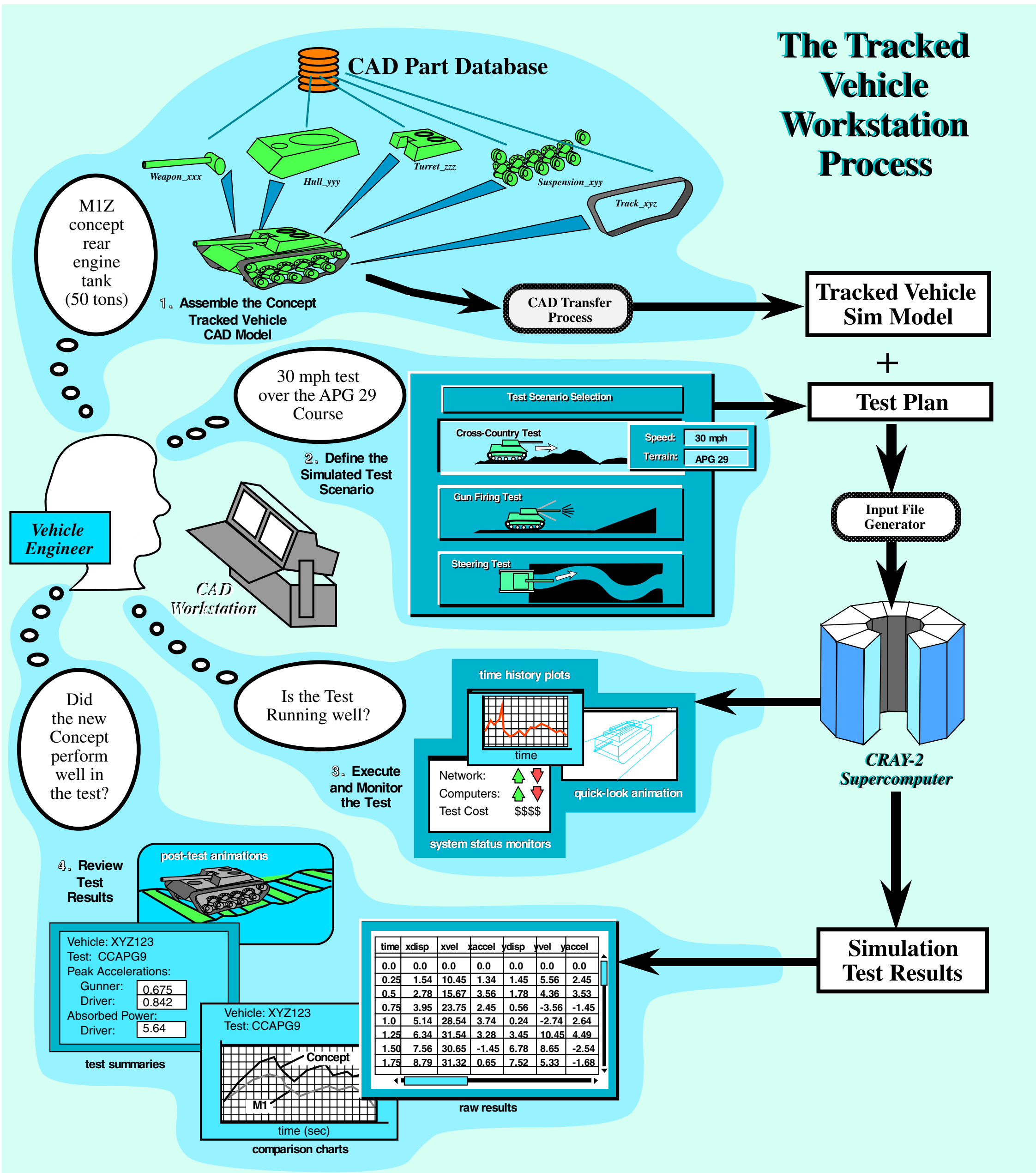

Figure 8-2. The Tracked Vehicle Workstation:
Expanding Vehicle Simulation's Role in the Vehicle Development Process

versus turreted vehicles and wheeled versus tracked are developed to meet requirements from the user community. Two-dimensional drawings of the conceptual vehicles can be produced from a CAD station.

Step 2: *Performance Modeling* – Analytical models applied to the solid model permit evaluation of mobility, stealth, survivability, vulnerability, lethality and vehicle dynamics. Results of the analyses are reflected through changes to the solid model, optimizing design through an iterative process. Competing conceptual designs can be evaluated and trade-offs to satisfy conflicting requirements can be worked with the user.

Step 3: *Wargame Modeling* – Resulting conceptual vehicles are evaluated using initial, then more detailed M&S. Concept effectiveness screening is done using constructive models, such as GROUNDWARS and CASTFOREM.

Step 4: *Virtual Mockup/Detailed Design* – Using concurrent engineering, the selected concept goes into detailed design; the solid model is refined to incorporate actual components using the Tracked Vehicle Workstation as depicted in Figure 8-2. An engineer selects components from a CAD parts data base, and assembles the concept vehicle. Simulated test scenario(s) are defined using a data base constructed from previous instrumented tests and extrapolations.

A test of the CAD model is run in the virtual environment, with real-time quick-look animation available for monitoring. Test results are analyzed and, depending on performance, the CAD model of the concept vehicle is modified. A 3-D virtual prototype is developed in which the user can actually explore the inside of the vehicle and provide valuable human-machine interface feedback.

With virtual prototyping, an obvious progression would be to allow the user to fight the vehicle, by interfacing it with other constructive and virtual simulations, before construction of a crew station envelope (step 6).

Step 5: *Virtual Factory* – Actual manufacturing processes are engineered in parallel with the detailed design (step 4). Machine tool paths, production line set-up, material flows, assembly, etc. are laid out and simulated prior to implementation on the factory floor.

Step 6: *Crew Station Development* – The virtual mockup results in the design of a crew station envelope (simulator) to assess human-machine interfaces under static and dynamic conditions. The simulator is connected via the distributed simulation internet to enable users to evaluate the effect of the concept's design on tactics and force effectiveness.

Step 7: *Build and Test Hardware* – Fabrication of a test-bed vehicle is done in part, by directly outputting from the CAD station to numerically-controlled machines. The TARDEC's strategy for electronics integration is to use a laboratory hot-bench to resolve integration issues prior to building the actual electronics hardware.

Step 8: *Manufacturing* – The virtual factory provides the detailed layout for the manufacturing process. Any changes in design, resulting from test-bed evaluation, are fed back into the system to ensure compatibility with production line set-up, material flow, etc.

Production is based on CAD and computer-aided manufacturing (CAM) machine output to machines, providing for more accurate and faster parts manufacture. The goal is to electronically transfer parts' design directly to a flexible manufacturing facility for production, in the spirit of CALS implementation.

Step 9: *Field Support* – The virtual prototype process provides more responsive field support in terms of failure prediction, analysis and retention of the historical engineering data base. Electronic data transfer and flexible manufacturing also provide for expanded potential of a smaller industrial base; possibly reducing logistics spares warehousing.

Not all aspects of TARDEC's virtual prototype process exist today. However, the organization is making significant strides to closing the gaps.

8.4 Getting to the future state of M&S

Many of the enabling technologies, see Figure 8-3,[3] associated with emerging M&S and related tools that have the potential to contribute to the acquisition process, are commercially driven. While this allows DoD to leverage advances made in the commercial market for these technologies, others are of specific interest to the military. Development of these latter technologies will be determined by DoD's ability to marshal industry innovation in the direction of its interests.

Each of the enabling technologies can be assigned to a level of the notional hierarchy[4] of technologies shown in Figure 8-4.

At the base of the hierarchy are the standards and protocols employed within the environment. These include many of the standards associated with modern software systems, the exchange of product model data and simulation interoperability standards.

At the next level are the underlying collabo-

Enabling Technologies

Commercially Driven	DoD Driven
Data base management systems	Manufacturing Process Simulations
Man-machine interfaces	Engineering design models
Software engineering tools	Manned simulators
Local and wide area networks	Stochastic wargaming simulations
High Performance computers	Semiautomated forces
Computer image generators	Instrumented ranges
Microcomputer systems	Instrumentation
Microprocessors	Simulation construction tools
Memory	Multilevel security
Mass storage	DoD protocols
Display devices	DoD data bases

Figure 8-3. Enabling Technologies

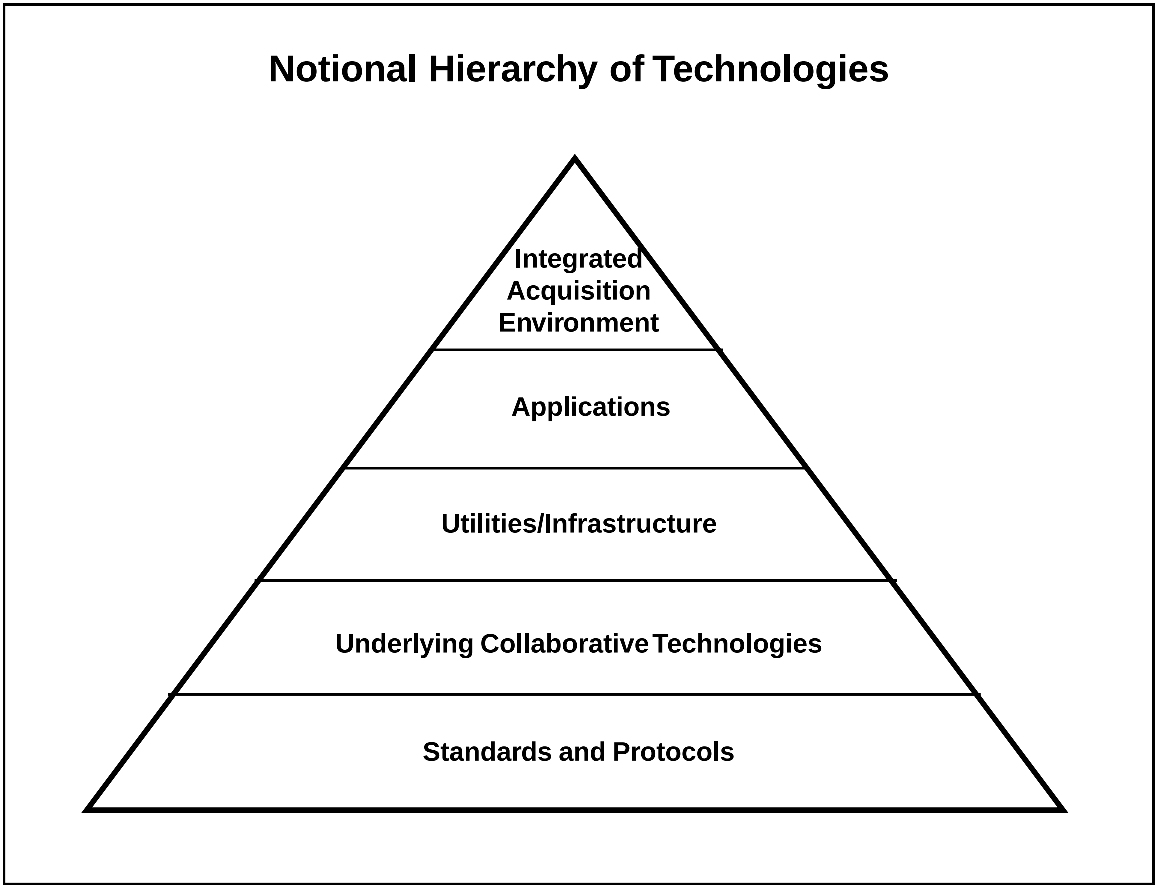

Figure 8-4. Notional Hierarchy of Technologies

rative technologies under development in academia and industry. These include efforts to establish shared electronic workspaces, develop customized software wrappers that facilitate the reuse of legacy code and to create Groupware -facilitating the work of groups separated in space and time (e.g. the Electronic Meeting Room).

Utilities/infrastructure are the third level of the hierarchy. These include significant existing capabilities such as moderately high capacity communications, data management tools and sophisticated human-machine interfaces.

The fourth level of the hierarchy consists of the applications being developed by the acquisition community. These applications are characterized by the type of tool (live, constructive or virtual simulation) and the functional discipline supported by the tool's employment (e.g. performance/effectiveness analyses, design/ engineering). Efforts to integrate applications within and across functional areas are logically supported by technologies at lower levels of the notional hierarchy.

The top level of the hierarchy is an integrated acquisition environment. This concept was introduced in Chapter 6, and is an infrastructure that supports the information needs of participants in the acquisition process by providing an integrated set of M&S; related tools—data base management, CAD/CAM, and computer-aided engineering (CAE); utilities—communications networks and data repositories; and policies and procedures for implementation.

8.5 Management Actions

Today's managers must understand the capabilities and limitations of M&S. They must also understand the challenges involved in managing and providing resources for the effort. As a start, managers are encouraged to

• Recognize that M&S are powerful tools that can offer significant opportunities to reduce the acquisition cycle time on a program.

• Recognize that M&S are not a panacea for all the issues confronting (and confounding) DoD's weapons system acquisition process. Modeling and simulation must add value—not be incorporated just because it is "the in thing."

• Managers must look down the life cycle and across the functional disciplines to identify what specific functions M&S can perform. Managers must also garner support from the various functional proponents for the conduct or support of specific tasks with M&S, using their expertise in the identification of the tasks.

• Gain user support for the conduct of specific user interface tasks with the support of M&S. User advocacy is critical to gain support for a viable M&S effort.

• Identify opportunities for achieving synergy through the integration of models and simulations. Here too, integration for "integration's sake" is counter-productive. Embrace standards and architectures facilitating interoperability and compatibility when they add value to the program. Else, it may inhibit management's flexibility in the long run.

• Plan and manage the M&S effort so that it meshes completely with the rest of the program; becoming a part of it. Programs whose acquisition strategies are developed to leverage the use of models and simulations are more likely to be the most efficient users. It is difficult, although not impossible, to restructure an on-going program to incorporate M&S. The biggest challenge is the allocation of time, money and people. A manager must identify and acquire the resources required to find, develop or modify these tools as early as possible.

• Designate a simulation manager within the program office, to advise you on all matters pertaining to M&S. As complex and visible as this area is getting, this individual must either have or obtain special training.

• Form a Simulation Working Group (SIMWG), chaired by the simulation manager with representatives from every element of the program team.

8.6 Some Application Best Practices

The purpose of this section is to provide some examples of using M&S in the acquisition process. The weapon systems discussed in this section are in various phases of acquisition. However, the perceived benefits are impressive enough to give cause to share them with the reader.

8.6.1 Combat System Engineering and Analysis Laboratory (CSEAL):

The CSEAL is a hardware/software-in-the-loop (HW/SWIL) simulation facility at Newport, Rhode Island, which allows for evaluation and rapid prototyping of submarine combat systems. It includes actual submarine computer systems and combat center displays which allow for integration of prototype systems, along with human-in-the-loop response, decision making and evaluation. It has been used in support of the AN/BSY-2 submarine combat system since 1988. This system performs many functions including sensor management and sensor data processing, sonar displays, mission planning, weapons systems targeting and other command functions such as weather and ocean condition predictions.

The AN/BSY-2 is a major software development project (3.6 million software lines of code) which has incorporated many sound software development practices.[5] The use of the CSEAL has been an ongoing part of this program. At the start of the program, it was used in conjunction with Navy operators to examine what functions the system should perform and how the information should be displayed to the operator. In 1988 it was then used to develop design specifications from the key system operating functions. As parts of the system are developed, the CSEAL has been used for independent verification and validation.

The CSEAL also has allowed data from live at-sea exercises to be used to stimulate the

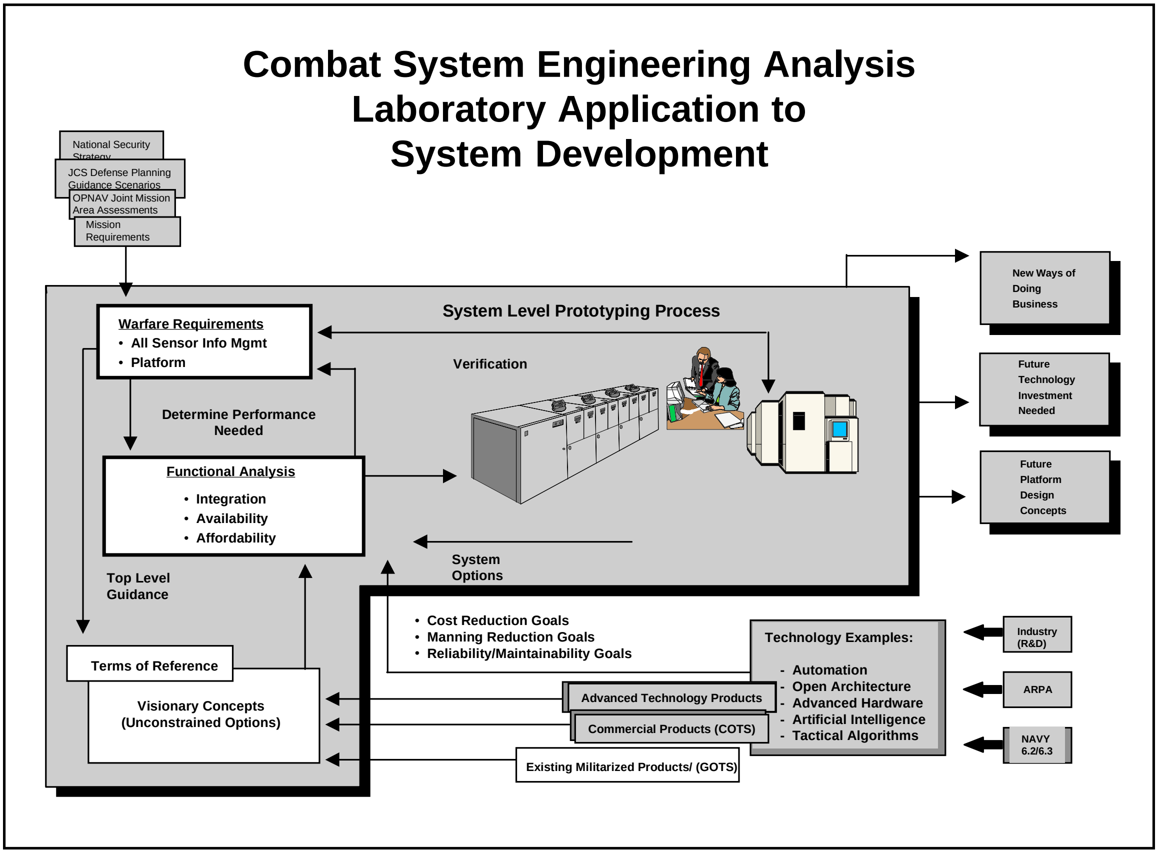

Figure 8-5. Combat System Engineering Analysis Laboratory Application to System Development

AN/BSY-2 system during the development process. Eventually the CSEAL may support design and evaluation of upgrades after the system is fielded.

This application of the CSEAL demonstrates how the simulation environment can support a program across the system life cycle. Figure 8-5 illustrates further how such a simulation laboratory can support the span of acquisition activities; including requirements definition, technology evaluation, concept development and system prototyping.[6]

8.6.2 Simulation support for Test and Evaluation - PM LONGBOW

The LONGBOW is a standoff, helicopter launched, anti-tank missile. A derivative of the HELLFIRE missile, it uses the same bus, but a millimeter wave seeker in place of HELLFIRE's laser-guided seeker. Re-using data and models from the HELLFIRE program and investing in a hardware-in-loop (HWIL) simulation facility, the LONGBOW engineering and manufacturing development (EMD) flight test program was reduced (from 50) to 20 missiles.

All test flights were first simulated in the HWIL facility using actual flight hardware. In several instances, potential flight failures were found and corrected before firing the missile down-range: resulting in time and money savings.

When the LONGBOW missile entered production, a Simulation/Test Acceptance Facility (STAF) was built at Redstone Arsenal, outside Huntsville, Alabama. The purpose of the STAF was to allow the LONGBOW PMO to effectively execute a production acceptance program and test the seeker without firing missiles. Components such as warhead, motor and battery are evaluated using the HELLFIRE fly-to-buy results, since these components are common to both missiles.

Estimated annual savings from the STAF is $7 million, with a payback period of under a year.

8.6.3 Modeling and Simulation in Specification Compliance and T&E - AIM-9X

The AIM-9X missile is a major improvement to the existing family of Sidewinder missiles. The AIM-9X will be used with selected aircraft to detect, intercept and destroy a wide range of high performance threat aircraft. This acquisition program is scheduled to begin Phase IV/I, Demonstration and Validation (DemVal), in January 1995. Extensive M&S will be used throughout the life cycle of the AIM-9X, from source selection to post-production software support activities.

The M&S activities will be used to reduce cost, reduce risks and ensure compliance with top level system performance specifications. These top level system requirements include those spelled out in the ORD in addition to other required/desired performance capabilities, interface requirements and "ilities" requirements.

Program cost reduction will be achieved by using M&S to reduce the number of missile test firings. A philosophy has been adopted that assumes M&S will be used to quantify system performance, and that hardware tests, of any kind, will be used to generate data for simulation validation.

A matrix of requirements versus methods to validate these requirements has been developed. The requirements were taken directly from the requirements correlation matrix (RCM) contained in the ORD, while methods to validate the requirements were selected from proposed simulations and hardware tests. A team of people familiar with simulations, testing and AIM-9X requirements generated this matrix; identifying the simulations and hardware tests necessary to validate each requirement. This process reduced the number of missile test firings by a factor of two from the original estimate generated using a conventional philosophy that did not rely primarily on M&S.

Simulations will be used to ensure compliance with performance specification requirements. For example, kinematic performance in the form of launch acceptability regions (LAR) is specified in the system specification, and will be evaluated using a validated six degrees-of-freedom (6-DOF) simulation. Program risk will be reduced by ensuring that required missile firings will have a very high probability of success (flight failures put programs in political jeopardy) and by continuously monitoring projected system performance to quickly identify issues that could become cost or schedule problems.

Finally, simulations will be used to convert hardware test results against available assets into equivalent performance against specified threats (i.e. captive flight tests performance against an F-18 used as a target aircraft must be translated into equivalent performance against the specified threat targets).

8.6.4 Modeling and Simulation in Source Selection, New Start - COMANCHE

Required by the government to use M&S to demonstrate their respective concepts, contractor teams for the RAH-66 COMANCHE made extensive use of virtual prototyping in the Army's newest aviation program. User interface was established with the contractor design team; with Army test pilots flying the virtual prototype. Insights gained from these flights, along with other contractual information, permitted the PM to down-select to a single source for the DemVal phase of the COMANCHE program.

8.6.5 Modeling and Simulation in Source Selection, Non-Developmental Item (NDI) - Non-Developmental Airlift Aircraft (NDAA)

The Air Force has been directed to evaluate the possible procurement of NDAA to complement a reduced quantity buy of C-17 strategic airlifters.

The data used to feed the Strategic Airlift Force Mix Analysis (SAFMA) comes from the Airlift Loading Model (ALM), and the Mobility Analysis Support System (MASS).

The ALM, managed by Air Force Studies and Analysis (AFSAA), is used to determine the amount of cargo each aircraft can carry. The model, in turn, depends upon data on standard pallet dimensions, vehicle sizes, weights and loads; typically required to meet mobilization requirements. This model is provided to potential bidders to familiarize them with tools to be used in source selection.

The mobility analysis support system (MASS), managed by US Transportation Command, is a time-phased force and deployment data (TPFDD) driven simulation which considers the amount of cargo and troops, as well as factors such as utilization rates, crew availability and airfield handling capacities.

A SAFMA is being used to provide information to the C-17/NDAA MS IIIB Defense Acquisition Board (DAB) pertaining to type(s) and number of NDAA to be procured to complement the C-17 fleet. This cost and operational effectiveness analysis (COEA)-like analysis provides cost benefit analysis between various possible mixes of C-17, NDAA and the current airlift fleet. The following information is provided to decision makers:

- Shortfalls in Mobility Requirements Study - Bottoms-Up Review Update (MRS-BURU);

- Evaluation of force mixes for additional aircraft needed to overcome shortfalls;

- Identification of options among force mixes that meet requirements;

- Life cycle cost analyses of those options found suitable; and

- Recommendations on force structures most effectively meeting requirements.

Measure of effectiveness (MOE) are used by the SAFMA to provide cost information of each aircraft alternative mix and performance; such as throughput tons per day, closure of combat units and total force; which could then be assessed against higher level measures of outcome (MOO) such as the effect(s) on a campaign.

The end result is a cost effective, time conservative, systematic approach to matching offerors' solutions to the user's requirements. It uses proven methods and validated models, de-emphasizing the empirical approach, and produces the COEA as an integral part of the overall study.

8.6.6 Modeling and Simulation in Source Selection, Upgrade - Bradley-Stinger

The Bradley-Stinger PMO issued a request for proposal (RFP) to three contractors, under a limited competition strategy, to obtain design specifications for candidate systems to fulfill the line-of-sight forward, heavy (LOS-F-H) air defense mission. The RFP included all requirements for the mission and required delivery of system specifications as part of the technical approach; along with relevant cost and schedule proposals. The PM's approach was to have the US Army Missile Command (MICOM), using the expertise resident within their Research, Development and Engineering Center (RDEC), develop a simulation based upon each of the three design specifications. The simulations were built to allow soldiers to operate the system in a synthetic environment, interacting with other virtual and constructive models.

A crucial aspect of the PM's management of this effort was the early involvement of all team members in a Simulation Working Group (SIMWG). The SIMWG included representatives from the PMO, contractor(s), user, model developer, tester, V&V agency and source selection authority.

Various aspects of the performance of each contractor's design in a synthetic environment were included as source selection criteria, along with cost and schedule.

8.7 Some Management Best Practices

8.7.1 Naval Undersea Warfare Center: Creating a Common Frame of Reference

The Naval Undersea Warfare Center has implemented a series of management practices that might be useful for the acquisition community to consider. These include a close working relationship with the sponsoring Program Executive Office (PEO) to develop a common frame of reference, CM practices and archival of simulation runs and data.

In this example, the Center and PEO staff have worked together to employ a common frame of reference providing for uniform application of models and simulations across all programs supporting that PEO. All systems rely on the same set of data books which contain the latest approved performance characteristics of friendly and enemy systems and environmental data. Consistent operational tactics (physical environment along with models validated with live test data) assures senior management that a common frame of reference is used to evaluate and assess systems. Management does not have to repeatedly question the methodologies, analysis approach, model validity or data source. This common framework also results in synergy, or better use of resources in support of all programs within that warfare area.

The CM practices for computer simulations include freezing the configuration of modules currently in use; running test cases for proposed changes; and finally documenting changes, developing manuals and notifying users of updates. For the HWIL simulators, a formal CM plan is in place that includes a configuration control board. These practices insure that current model and simulation configurations are properly validated and documented for use.

An audit trail for simulations is maintained. This includes archiving the actual model configuration and input data so any case can be recreated. This is vital when comparison analysis using a consistent baseline is requested at a future date, or for evaluation of changes.

Accomplishing these practices requires a management commitment. In many cases, program offices are focused on near-term objectives, but they also should consider the ongoing maintenance which is necessary to provide them, as well as senior leadership, with a capability at a future date.

8.7.2 Modeling and Simulation Management - BAT

Originally “Brilliant Anti-Tank,” the BAT sub-munition was being developed to kill second and third echelon enemy moving tank formations. The BAT’s system effectiveness was defined using 672 different conditions. A test program involving statistically valid information for each condition would have been unaffordable. Faced with the task of designing a complex and prohibitively expensive test program, the PMO received DAB approval to evaluate the BAT performance and effectiveness using simulations subjected to rigorous verification, validation and accreditation (VV&A).

The BAT program uses a family of simulations that collectively contribute to system effectiveness prediction.

The BAT system validation process, shown in Figure 8-6, is iterative; using test data to validate the simulation. Furthermore, the BAT PMO developed its system simulation independent from the prime contractor, but from the same specifications. Each model is used as a cross-check on the other.

The BAT test methodology, shown in Figure 8-7, uses the model-test-model concept to ensure that the system model is kept in sync with the tactical design. Predictions from pre-test runs of the model are compared with post-test analyses to ensure that any differences can be explained, or form the basis for a modification.

The BAT PMO formed a SIMWG consisting of a wide constituency and a team approach to validation and accreditation. Acceptance of simulation results in support of operational testing is simplified through shared responsibility of the operational test

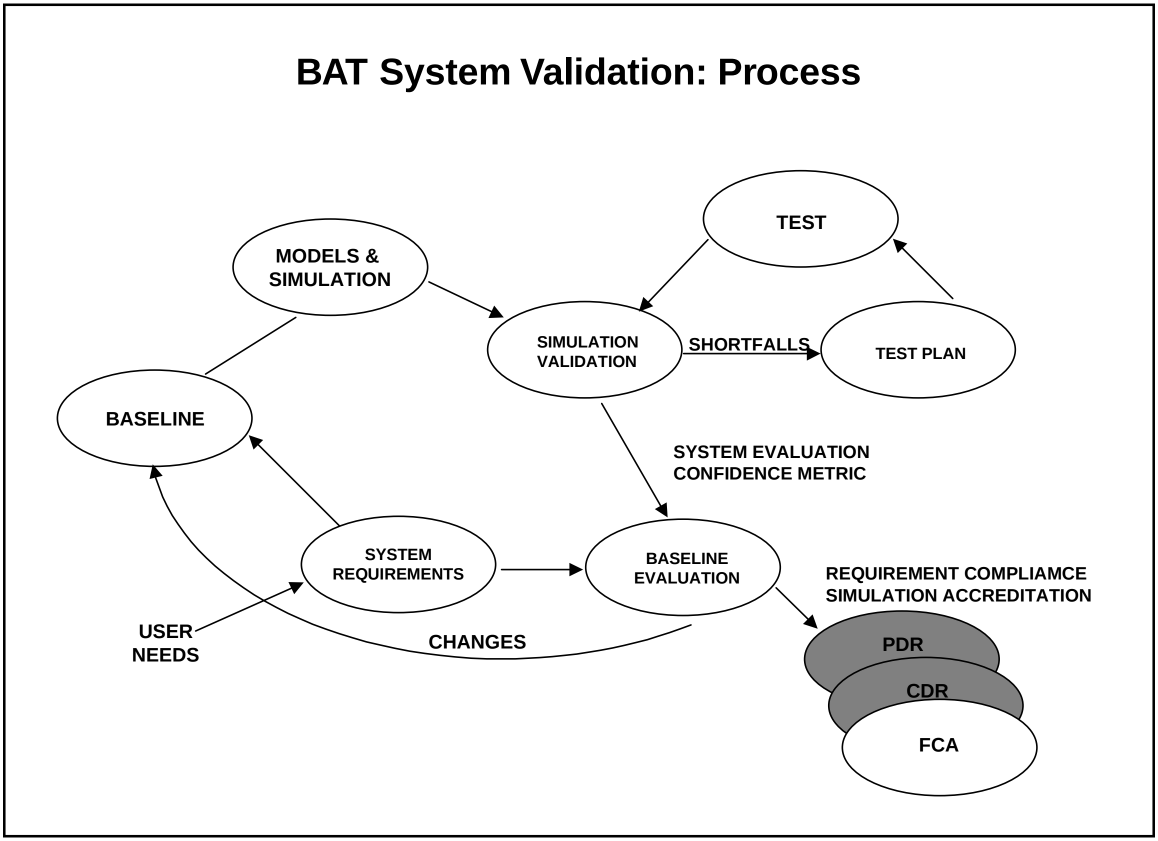

Figure 8-6. BAT System Validation: Process

accreditation process by the BAT PMO and the sponsor (Army's Operational Test and Evaluation Command).

The BAT SIMWG implemented a solid CM approach involving configuration baselining, change control, evaluation and processing. Release of simulations is controlled through execution of a Memorandum of Understanding (MOU) with each user; as well as maintenance of a data base of users, what they have (documentation, software, sample cases) and the simulation version.

The BAT program is recognized as a case study in the use of teaming to accomplish effective use and control of performance and effectiveness M&S.

8.7.3 Simulation Management - TOMAHAWK Cruise Missile

The TOMAHAWK cruise missile program has had a simulation management board in place for approximately ten years. This simulation management provides many functions which include:

- Maintaining a simulation catalog containing a description of each simulation, technical status, limitations, functions and current utilization. Entry into the catalog is part of the simulation certification process and only those simulations in the catalog may be used to define performance capability and system effectiveness estimates.

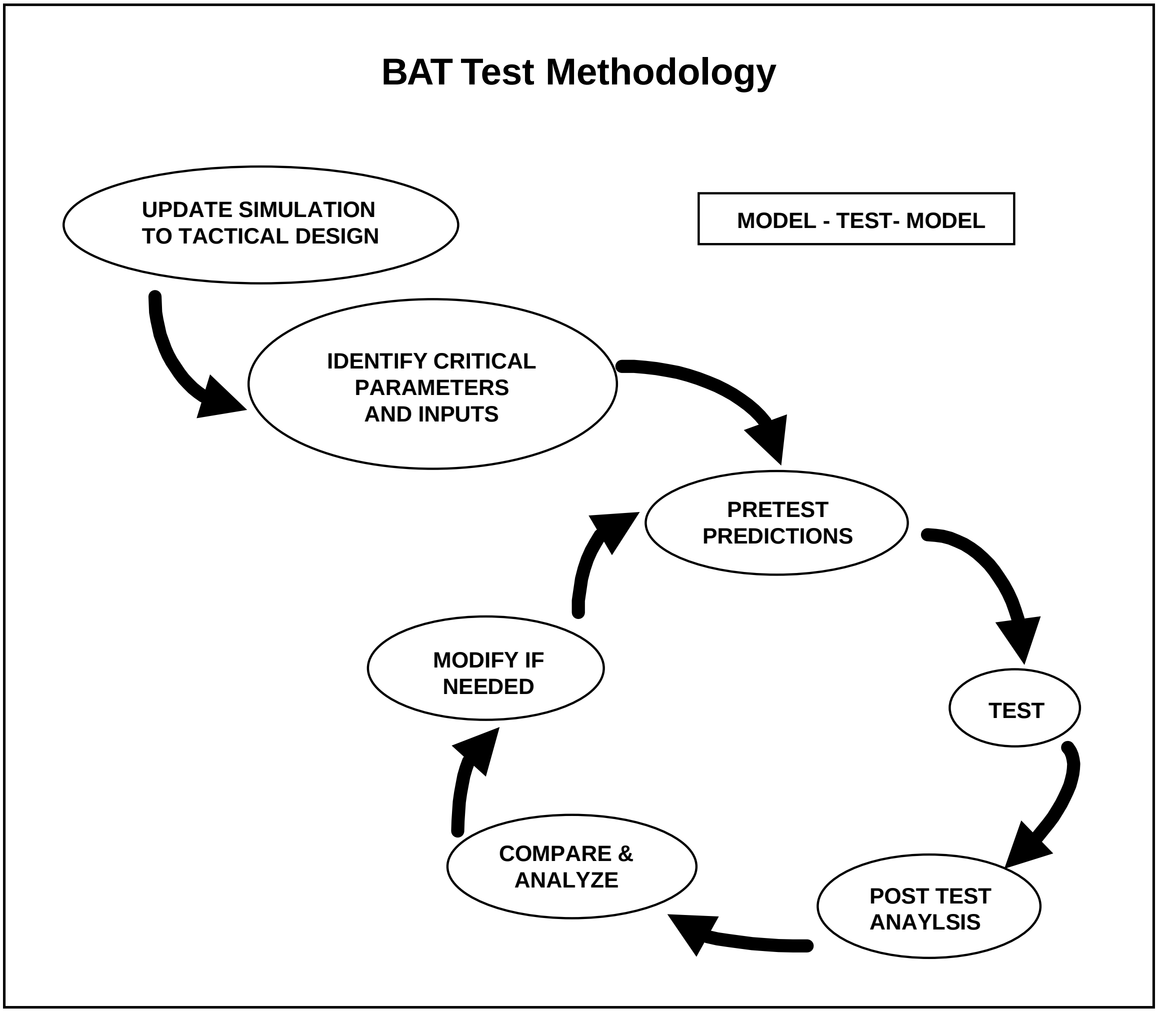

Figure 8-7. BAT Test Methodology

• Integrating individual simulation status and plans within TOMAHAWK program plans.

• Maintaining a set of authorized reference simulations which serve as performance baselines for the missile and for evaluation of proposed changes. Reference check cases are defined with inputs, initial conditions, assumptions and expected outputs; typically validated by test data.

• A method of documenting/disclosing the pedigree (certification) status of a simulation: a certificate which is approved by the chairman of the simulation management board. This certificate, shown in Figure 8-8, is used when publishing or presenting performance analysis results.

The value of this management process is coordination of simulation plans across the entire program, providing standard reference simulations and check cases and central management of certified TOMAHAWK models and data bases for use; eliminating

TOMAHAWK Simulation Mangement Board Certificate

To: (Responsible Organization) ____________________

From: TOMAHAWK Simulation Management Board

Subject: (Full/Provisional/Limited) Certification of TOMAHAWK __________ {Simulation Name}

Certified to Represent ____________ **for use in:** ____________

(Define domain of certification applicability)

Responsible Organization: ____________________

This (Full/Provisional) Certification is for:	The following material support certification:
Version ______ Dated ______	___ Certification Plan ___ Certification Report ___ Configuration Control Plan ___ Current Catalog Entry
Provisional Pending: ______	___ Users Manual ___ Benchmark Checkcases ___ Reference Checkcases ___ Source Code/Listing
Based on the following major activities: _____ Validation against Flight Test Results _____ Validation against ______ _____ Other ______	
Previous Certification: Version ____ Dated _____	

Certification Recommended:

SCP Chairman: ______________

SCP Co-Chair: ______________

Certification Approved:

____

Chairman, Simulation Management Board, Date

Figure 8-8. TOMAHAWK Simulation Management Board Certificate

redundancy of multiple simulation development efforts and potential errors.[7]

8.8 Summary

The instances discussed in the preceding sections are only representative of the many successful uses of M&S in systems acquisition. The cases mentioned, however, reinforce a significant aspect of the use of M&S in acquisition. Careful early planning and investment for the use of M&S will pay dividends through cost avoidance. While cost avoidance is not as easy to quantify or project, as cost savings, the results for an institution facing a downward trend in budgets, are just as tangible.

ENDNOTES

1. Hartley, J. R. (1992) *Concurrent Engineering: Shortening Lead Times, Raising Quality, and Lowering Costs.* Cambridge, MA.

2. "CATIA Data Management and CATIA Data Management Access," p.1.

3. Garcia, A. B., Gocke, R. P. Jr., Johnson, N. P. Jr. (1994) *Virtual Prototyping: Concept to Production," Report of the 1992-1993 Military Research Fellows.* (p. 36). Ft. Belvoir, VA: Defense Systems Management College.

4. Final Report of the Acquisition Task Force on Modeling and Simulation, June 1994.

5. "BSY-2 Ada Lessons Learned", F.Gregory Farnham, 1993 Washington Ada Symposium, ACM 0-89791-609-3/93-0006-95.

6. Naval Undersea Warfare Center, Newport, RI.

7. "TOMAHAWK Simulation Management, a Working Example", Van D. Underwood, Chairman, TOMAHAWK Simulation Management Board, Johns Hopkins University Applied Physics Laboratory, San Diego, California 92124.

EPILOGUE

The use of modeling and simulation (M&S) in defense acquisition is certain to grow dramatically in coming years. Advances in simulated battlefield environments will support models possessing the resolution and fidelity to address the complex issues at hand. The extension of innovative implementations of advanced concepts, such as Distributed Interactive Simulation (DIS), are creating exciting, cost effective means for the conduct of wargaming, training, and requirements and concept development. The use of M&S tools is expanding within each functional domain of weapon systems acquisition. Integration of tools used among the functional domains is beginning as a natural follow-on.

The primary intent of this document is stated in the title. However, the authors feel compelled to include a vision of how things may be in the not-too-distant future, as well as to reiterate some advice to Program Managers (PMs) and policy makers.

Economic, political, national, and international forces are responsible for much of the recent reorganization and process re-engineering within the Department of Defense (DoD). During the conduct of this research, we witnessed new ideas germinating and products taking shape in response to these changes. These ideas are, largely, the result of a recognition that DoD must use its resources with greater efficiency. An inevitable result of these innovations will be a better, more focused and timely allocation of resources.

A logical next step is an intense focus on mission areas and their requirements from a truly joint perspective. For example, if all services participate in the counter-air mission area, why not approach the Mission Area Assessment (MAA) and Mission Needs Analysis (MNA) from an all-service contribution standpoint? The potential for M&S to play a major role in contributing to such analyses, is significant.

Individual PMs must understand what M&S tools can do for their programs, as well as recognize their limitations. They (M&S tools) offer significant benefits, but are not a panacea. The PMs must recognize that the management of M&S efforts require resource investments, and that the resulting *benefits are usually in cost avoidance rather than* cost savings. Each PM must also recognize that any program will normally require the support of several models and simulations, and that additional benefits may accrue from the integration of some of these tools.

Policy makers, on the other hand, must recognize the PM's lot. Efforts to institutionalize the use of M&S in weapon systems acquisition must be based on an assessment of the value added. Guidance should, and must, be provided. However, it must be judicious in its mandate. PMs must be provided the latitude to do what is smart for their individual programs.

Policy that adds baggage without creating value will stifle the very innovation so crucial to achieving the synergy that the application of M&S tools is capable of providing.

APPENDIX A
DoD SOURCES OF INFORMATION FOR MODELING AND SIMULATION IN WEAPON SYSTEMS ACQUISITION

This appendix contains a listing of points of contact for modeling and simulation within the Office of the Secretary of Defense (OSD), Department of Defense (DoD) Agencies and the Joint Staff.

Defense Modeling and Simulation Office (DMSO)
Phone:(703)998-0660

Advanced Research Projects Agency (ARPA)
Advanced Systems Technology Office (ASTO)
Phone:(703)696-2309
DSN: 226-2309

Ballistic Missile Defense Office (BMDO)
Modeling and Simulation Directorate (AQM)
Phone:(703)693-1594
DSN: 223-1594

Defense Intelligence Agency (DIA)
Acquisition/Plans Intelligence Support Division (PAN-2)
Phone:(202)373-3101
DSN: 243-3101

Defense Information Systems Agency (DISA)
Center for Standards
C3I Support Division (TBC)
Phone:(703)487-3538
DSN: 364-3538

Information Processing Standards Division (TBE)
Phone:(703)487-3552
DSN: 364-3552

Defense Logistics Agency (DLA)
Warfighting and Integration Division (CAILW)
Phone:(703)274-6715
DSN: 284-6715

Defense Mapping Agency (DMA)
Plans and Requirements Directorate
Advanced Weapon & Systems Division (PRW)
Phone: (703)285-9326
DSN: 356-9326

Defense Nuclear Agency (DNA)
Operational Support(OPNA)
Phone: (703)325-7177
DSN: 221-7177

National Defense University (NDU)
War Gaming and Simulation Center (NDU-NSS-WGSC)
Phone: (202)475-1251
DSN: 335-1251

THE JOINT STAFF

Director for Logistics (J4)
Mobility Division (J4/MOB)
Phone: (703)697-6110
DSN: 227-6110

Director for Command, Control, Communication, and Computer Systems (J6)
Resource, Planning, and Evaluation Division (J6E)
Phone: (703)697-8590
DSN: 227-8590

C4 Architecture and Integration Division (J6I)
Phone: (703)614-8787
DSN: 224-8787

Director for Operational Plans and Interoperability (J7)
Joint Simulation Division (J7/JSID)

Policy
Phone: (703)695-3047
DSN: 225-3047

Joint Test/Evaluation
Phone: (703)693-3418
DSN: 223-3418

Joint Warfighting Center (JFWC-CC)
Phone: (904)884-7720
DSN: 579-7720

Director for Force Structure, Resources, and Assessment (J8)
Automated Systems Division (J8/ASD)

Applications
Phone: (703)697-7824
DSN: 227-7824

Data Bases
Phone: (703)697-8899
DSN: 227-8899

H/W Configuration
Phone: (703)693-4614
DSN: 223-4614

Resources and Joint Planning Division (J8/RJPD)

Contracts
Phone: (703)614-7881
DSN: 224-7881

Contracted Advisory and Assistance Services (CAAS)
Phone: (703)693-4608
DSN: 223-4608

Modern Aids to Program Planning (MAPP)
Phone: (703)695-1763
DSN: 225-1763

System Programs Evaluation Division (J8/SPED)
Phone: (703)697-6299
DSN: 227-6299

CATALOGS:

Catalog of Wargaming and Military Simulation Models. (1992). (12th ed.) Washington, DC: Force Structure, Resource, and Assessment Directorate, Technical Support and Operations Division (J-8/TSOD), The Joint Staff.

APPENDIX B

DEPARTMENT OF THE ARMY SOURCES OF INFORMATION FOR MODELING AND SIMULATION IN WEAPON SYSTEMS ACQUISITION

This appendix is organized primarily to assist Army acquisition managers in their search for information regarding modeling and simulation (M&S) activities of various Army organizations. It provides phone numbers, office symbols and addresses to assist users in making initial contact. This appendix also provides information on Model and Simulations: Army Integrated Catalog (MOSAIC). Figure B-1 depicts the relationship of organizations active in the Army's development, management and use of M&S in acquisition.

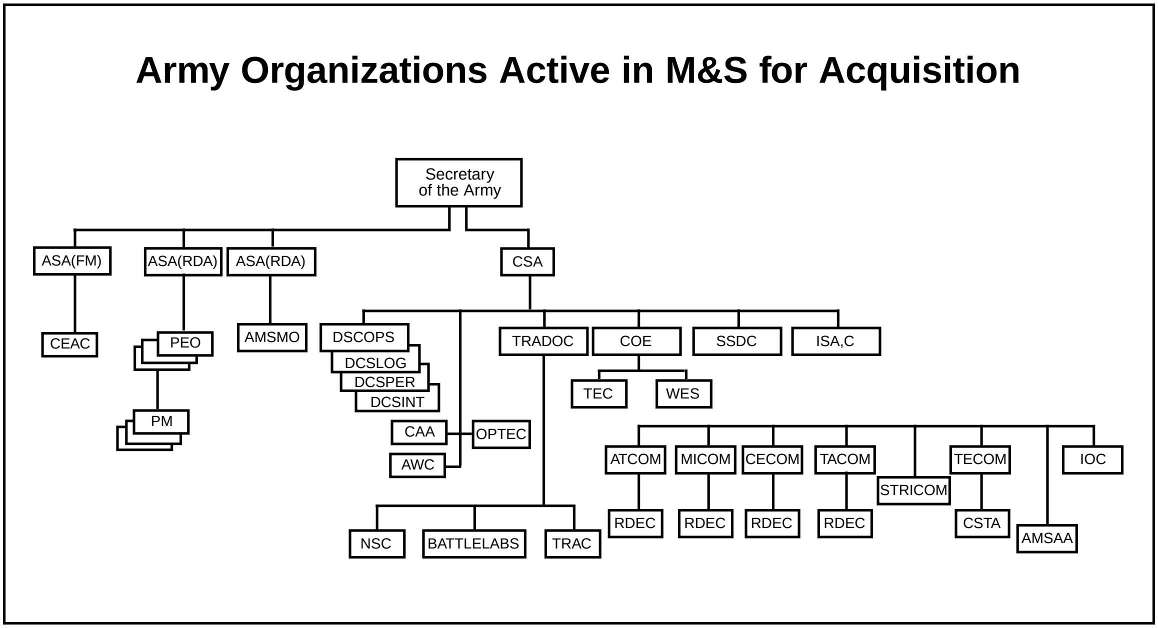

Figure B-1: Army Organizations Active in M&S for Acquisition

POLICY AND GUIDANCE

Army Model and Simulation Management Office (AMSMO): The AMSMO promulgates Army M&S policy; publishes guidance and administers the Army Model Improvement Program (AMIP) and Simulation Technology Program (SIMTECH); develops and publishes the Army Model and Simulation Master Plan and implementing procedures such as the verification, validation and accreditation (VV&A) of Army models and simulations.(The AMSMO will be the focal point for establishing and maintaining the media by which to identify and share information on agencies, organizations and activities in the Army community who use or develop M&S.) The point of contact (POC) is:

U.S. AMSMO
1725 Jefferson Davis Highway, Suite 808
Arlington, VA 22202
Phone: (703)607-3375

POCS FOR ANALYSIS MODELS (BY FORCE LEVEL)

System Performance Models, Item level: Focusing on a single weapon system or piece of equipment. Examples include: Air Defense Air-to-Ground Engagement (ADAGE), Artillery Force Simulation Model (AFSM), Simplified Artillery, Reliability Growth model (e.g. SESAME), Projectile Effectiveness Model (e.g. ARTQUIK), TANKWARS, NATO Reference Mobility Model. The POC is:

U.S. Army Materiel Systems Analysis Activity (AMSAA)
Special Studies and Activities Office
ATTN:AMXSY-DA
Aberdeen Proving Ground, MD 21005-5071
Phone: (410)278-6576
DSN: 298-6576

Brigade and task force level, and below: Focusing on combined arms forces and single functional elements; they are represented as an integral part of combined arms and services activities. Examples include: Combined Arms and Support Task Force Evaluation (CASTFOREM), JANUS(T), ELANT, American Canadian Australian British Urban Game (ACABUG). The POC is:

Commander, U.S. Army TRADOC Analysis Command (TRAC)
Brigade/Battalion Modeling and Analysis Support Center
ATTN:ATRC-WE
White Sands Missile Range, NM 88002-5502
Phone: (505)678-1012
DSN: 258-1012

Corps and Division Level: Focusing on single and multi-division levels of operation with or without a supervising corps headquarters. Examples include: EAGLE, Corps Battle Analyzer (CORBAN), Vector-in-Commander (VIC), JIFFY. The POC is:

Commander, U.S. Army TRADOC Analysis Command (TRAC)
Corps/Division Modeling and Analysis Operations Analysis Directorate Support Center
ATTN:ATRC-OAC
Ft. Leavenworth, KS 66027
Phone: (913)684-2276
DSN: 552-2276

Theater level and above: Focusing on all force levels at echelons above corps; includes multi-corps, regional and global models and simulations. Examples include: Force Evaluation Model (FORCEM), Concepts Evaluation Model V (CEM V), Force Analysis Simulation of Theater Administrative and Logistic Support (FASTALS), Transportation Model (TRANSMO). The POC is:

Commander, U.S. Army Concepts Analysis Agency (CAA)
Research and Analysis Support Directorate
ATTN:CSCA-RS
8120 Woodmont Ave
Bethesda, MD 20814
Phone: (301)295-1692
DSN: 295-1692

POCs by M&S Functional Application

Engineering Models: Information focusing on models and simulations which augment design, engineering and testing in various stages of the materiel acquisition process. Models and simulations are used in investigating mechanical, electrical and physical phenomena associated with the functioning of an item or system. Examples include hardware-in-the-loop (HWIL), six degree-of-freedom (6-DOF), physics-of-failure simulations, computer-aided design (CAD), computer-aided manufacturing (CAM) and phenomenology models. The POCs at the various Research, Development and Engineering Centers (RDEC) are:

Commander, U.S. Army Communications-Electronics Command (CECOM)
Research, Development and Engineering Center (CRDEC)
ATTN:AMSEL-RD-ST-CE-M
Ft. Monmouth, NJ 07703-5203
Phone: (908)544-4708
DSN: 992-4708

Commander, U.S. Army Close Combat Armament Center
Light Armament Division
ATTN:SMCAR-CCL-E
Picatinny Arsenal, NJ 07806-5000
Phone: (201)724-6054
DSN: 880-6054

Commander, U.S. Army Fire Support Armament Center
Fire Control Division
ATTN:SMCAR-FSF-BD
Picatinny Arsenal, NJ 07806-5000
Phone: (201)724-7920
DSN: 880-6054

Commander, U.S. Army Missile Command (MICOM)
ATTN:AMSMI-RD-SS
Redstone Arsenal, AL 35898-5252
Phone: (205)876-4271
DSN: 746-4271

Commander, U.S. Army Tank-Automotive Command (TACOM)
ATTN:AMSTA-RYA
Warren, MI 48397-5000
Phone: (313)574-8633
DSN: 786-8683

Commander, U.S. Army Aviation and Troop Command (ATCOM)
ATTN:AMSAT-R-B
4300 Goodfellow Blvd.
St. Louis, MO 36120-1798
Phone: (314)263-1333
DSN: 693-1333

Commander, U.S. Army Edgewood RD&E Center
ATTN:SCBRD-RTM
Aberdeen Proving Ground, MD 21010-5423
Phone: (410)671-1774
DSN: 584-1774

Commander, U.S. Army Natick RD&E Center
ATTN:SATNC-AAM
Kansas Street
Natick, MA 01760-5015
Phone:(508)651-4881
DSN: 256-4881

Director, U.S. Army Research Laboratory (ARL)
2800 Powder Mill Road
Adelphi, MD 20783-1145
Phone:(301)394-4650
DSN: 290-4650

Cost Models: The U.S. Army Cost and Economic Analysis Center (CEAC) develops and screens models that pertain to financial management (e.g. cost analysis); designs and implements the cost methodology for program office estimates and component cost analysis that shape the Army cost position. The CEAC develops data bases, cost models and cost estimating relationships for major materiel systems; tracks operating and support costs; captures demand data and scales it to activity or use; uses M&S to cost real time sustainment cost during the battlefield simulations; develops and screens M&S pertaining to manpower costs; and tracks the personnel costs to operate the force. The POC is:

Director, U.S. Army Cost and Economic Analysis Center (CEAC)
ATTN:SFFM-CA-CR
5611 Columbia Pike, Room 436
Falls Church, VA 22041-5050
Phone: (703)756-8732
DSN: 289-8732

Logistics Models: The U.S. Army Logistics Support Agency (LOGSA) develops and manages techniques/models for performing logistics support analysis (LSA) and logistics support analysis reports (LSAR); is responsible for policy, techniques/ models and data elements for level of repair analysis (LORA); is proponent, developer and configuration manager of three of the currently designated Army standard LORA techniques/models; performs LORA on designated weapon systems; and provides consultation and guidance on performing LORA for all Army weapon systems. The POCs are:

Executive Director, AMC LOGSA
ATTN:(See Below)
Redstone Arsenal, AL 35878-7466
Phone Hotline: 1-800-553-0764/0769

For LORA: ATTN:AMXLS-AL
FOR LSA/LSAR: ATTN:AMXLS-ALD

Manpower Models: The Office of the Deputy Chief of Staff for Personnel (DCSPER), Director for Manpower and Personnel Integration (MANPRINT) has oversight for development of M&S for soldier survivability and manpower, personnel and training integration. The POC is:

HQDA, ODCSPER, Director for MANPRINT
ATTN: DAPE-MR
The Pentagon
Washington, DC 20310-0300
Phone:(703)697-9213
DSN: 227-9213

Manufacturing Models: Since these models are usually weapon system, material and technology specific, a **central** POC is:

Commander, U.S. Army Materiel Command, Manufacturing Science and Technology Office
ATTN:AMCRD-IEM
5001 Eisenhower Avenue
Alexandria, VA 22333-0001
Phone: (703)274-9437
DSN: 284-9437

TESTING:

Developmental Testing: The various RDECs possess inherent capabilities to conduct technical testing at various stages of the acquisition process. To support formal developmental testing, the U.S. Army Test and Evaluation Command (TECOM) develops and supports M&S for vibration and environmental testing; uses M&S for meteorology studies for test planning and to drive simulation targets in moving target simulators; and is developing a virtual test range in support of virtual prototyping and other simulation exercises. The POC is:

Commander, TECOM, Technology Development Division
ATTN:AMSTE-CT-T
Aberdeen Proving Ground, MD 21005-5055
Phone:(410)278-1479
DSN: 298-1479

Operational Testing: The U.S. Army Operational Test and Evaluation Command (OPTEC) is the Army's lead agent for operational test and evaluation; using M&S throughout the testing process, OPTEC applies cost effective techniques to situations of limited testability; and incorporates the notion of distributed interactive simulation (DIS) through the use of constructive and virtual simulations in the live simulations (operational tests) that it conducts. The POC is:

Commander, U.S. Army OPTEC, Office of Policy and Methodology
ATTN:CSTE-MP
Park Center IV, 4501 Ford Avenue
Alexandria, VA 22302-1458
Phone:(703)756-1685/1688
DSN: 289-1685/1688

Training: The Simulation, Training and Instrumentation Command (STRICOM) manages the development and acquisition of simulations to support training, exercises, and military operations. The various Program Managers are: PM – Training Devices (PM-TRADE); PM – Instrumentation, Targets and Threat Simulators (PM-ITTS); PM – Combined Arms Tactical Trainer (PM-CATT); and PM – Distributed Interactive Simulation (PM-DIS). Central POC is:

Commander, U.S. Army STRICOM, Director for Management
ATTN:AMSTI-M
12350 Research Parkway
Orlando, FL 32826-3276
Phone:(407)380-8234
DSN: 960-8234

M&S DATA SOURCES

Weapon Systems Performance Data: Item level weapon systems performance data for U.S. and threat systems, and characteristics data for U.S. systems. Data focusing on the lowest level system, such as a gun with its crew or a tank with its crew (includes reliability and supportability). The POC is:

U.S. Army Materiel Systems Analysis Activity (AMSAA)
Special Studies and Activities Office
ATTN:AMXSY-DA
Aberdeen Proving Ground, MD 21005-5071
Phone:(410)278-6576
DSN: 298-6576

Threat Systems Performance Data: Item level weapon systems operational and characteristic data for threat systems focusing on lowest level threat systems, such as an air defense gun or tank. The POC is:

HQDA, Office, Deputy Chief of Staff for Intelligence (ODCSINT)
ATTN:DAMI-FIT
The Pentagon
Washington, DC 20310-1088
Phone:(703)614-8121
DSN: 224-8121

Weather Data: The POC is:

Director, U.S. Army Research Laboratory (ARL)
2800 Powder Mill Road
Adelphi, MD 20783-1145
Phone:(301)394-4650
DSN: 290-4650

Terrain Data: The POC is:

Director, U.S. Army Topographic Engineering Center (TEC)
7701 Telegraph Road
Alexandria, VA 22310-3864
Phone:(703)355-3176
DSN: 345-3176

Smoke Data: The POC is:

Director, U.S. Army Research Laboratory (ARL)
2800 Powder Mill Road
Adelphi, MD 20783-1145
Phone:(301)394-4650
DSN: 290-4650

OTHER ORGANIZATIONS WITH SPECIFIC M&S RESPONSIBILITIES AND CAPABILITIES

U.S. Army Materiel Systems Analysis Activity (AMSAA): The AMSAA uses M&S to provide U.S. and threat systems performance data for use in cost and operational effectiveness analyses (COEA), in Army studies, and in support of the acquisition of systems; helps accredit and provides certified systems performance data characteristics and data to the Army community; provides VV&A support to U.S. Army Materiel Command (AMC) and other agencies; promulgates VV&A and data certification policy throughout AMC; and, in conjunction with TRADOC, standardizes data and algorithms within the Army community. The AMSAA maintains configuration control on M&S for item level performance, one-on-one system performance, few-on-few and many-on-many combat and large war gaming simulation. The POC is:

U.S. Army Materiel Systems Analysis Activity (AMSAA)
Special Studies and Activities Office
ATTN:AMXSY-DA
Aberdeen Proving Ground, MD 21005-5071
Phone:(410)278-6576
DSN: 298-6576

U.S. Army Industrial Operations Command (IOC): Formerly the U.S. Army Armament, Munitions and Chemical Command. The IOC's Cost and Systems Analysis Directorate provides and uses M&S to assess manufacturing and flexible computer integrated manufacturing and repair operations at the macro and micro level within the arsenals, the depots and the ammunition plants. The POC is:

Commander, Industrial Operations Command
ATTN:AMSMC-AN
Rock Island, IL 61299-6000
Phone:(309)782-5262
DSN: 793-5262

National Simulation Center (NSC): The TRADOC proponent for all battle command training simulations. The NSC sponsors, designs, maintains and provides configuration management (CM) of all Army battle command training M&S; and coordinates, manages, and executes training simulation V&V. The POC is:

Commander, Combined Arms Center
ATTN:ATZL-NSC
Ft. Leavenworth, KS 66027-7305
Phone:(913)684-8101
DSN: 552-8101

TRADOC Battle Labs: The Battle Labs use models and simulations, as well as other tools, to improve battlefield capabilities by deriving insights across doctrine, training, leader development, organization design and materiel (DTLOM). Central POC is:

Commander, U.S. Army TRADOC
ATTN:ATCD-B
Ft. Monroe, VA 23651-5000
Phone:(804)727-4283/4284
DSN: 680-4283/4284

U.S. Army Space and Strategic Defense Command (USASSDC): The USASSDC applies M&S in conducting research and development (R&D) of missile defense simulations. The POC is:

Commander, Space and Strategic Defense Command
ATTN:CSSD-CR
PO Box 1500
Huntsville, AL 35807-3801
Phone:(205)955-1354
DSN: 654-1354

U.S. Army War College (AWC): The AWC's Center for Strategic Leadership uses M&S in support of students and curriculum. The Center uses M&S for war gaming, simulation support, and studies; analysis for other Army and DoD commands and agencies at the operational and strategic levels of war; and provides limited development of M&S education decision tools. The POC is:

Commandant, U.S. Army War College
ATTN:AWC-AW
Carlisle Barracks, PA 17013-5050
Phone:(717)245-4281
DSN: 242-4281

THE MODELS AND SIMULATIONS: ARMY INTEGRATED CATALOG (MOSAIC)

The MOSAIC provides potential model developers and users the opportunity to peruse the array of existing M&S and query the hypertext system for all information of interest to them in their proposed application. The official registry of M&S, MOSAIC contains all active and developmental M&S.

In AR 5-11, Army M&S proponents are directed to:

- Enter information about their M&S into the catalog

- Keep that information current by providing updates at least every two years

To become and remain a valid entry in MOSAIC, a model or simulation must:

- Be computerized

The POC for MOSAIC is:

Chief, Army Model and Simulation Management Office (AMSMO)
ATTN:SFUS-MIS (MOSAIC System Administrator)
1725 Jefferson Davis Highway, Suite 808
Arlington, VA 22202
Phone:(703)607-3383
DSN: 327-3383

ARMY POLICY AND PROCEDURE REFERENCES

Army Regulation 5-11, *Army Model and Simulation Management Program* (AMSMP): Prescribes policy for Army M&S management and formalizes the Army's program for management of models and simulations.

Department of The Army Pamphlet 5-11, Verification, Validation, and Accreditation of Army Models and Simulations: Provides procedures to assist model developers, proponents and sponsors to conform to the policies in AR 5-11.

Army Model and Simulation Master Plan: Promotes the adoption of standards and common tools and processes in building and populating models and simulations, for use in all applications throughout the Army.

OPTEC Handbook 73-21: Written primarily for OPTEC's evaluators, test officers and analysts. It assists OPTEC personnel in coordinating more proficiently with external parties with respect to the use of M&S in support of OT&E. Likewise, it allows managers to be pro-active in their M&S planning efforts.

APPENDIX C
DEPARTMENT OF THE NAVY SOURCES OF INFORMATION FOR MODELING AND SIMULATION IN WEAPON SYSTEMS ACQUISITION

This appendix provides information on various organizations within the Department of the Navy (DON) that are involved with modeling and simulation (M&S) activities. It provides phone number, office codes and addresses to assist users in making initial contact.

Assistant Secretary of the Navy (Research, Development and Acquisition)

The ASN(RDA) has overall responsibility for Navy acquisition. It provides guidance on development and use of models in the acquisition process. ASN(RDA) is a member of the DON M&S Oversight Council. The point of contact (POC) is:

Assistant Secretary of the Navy (Research, Development and Acquisition)
The Pentagon
Washington, DC 20350-1000
Phone: (703) 695-2843
DSN: 225-2843

Chief of Naval Operations, Space and Electronic Warfare Directorate (N6)

The Navy's Policy and Coordination Office for Modeling & Simulation is expected to be established in this directorate during the summer of 1994. The specific office had not been determined as of May 1994. The POC is:

Chief of Naval Operations (N6)
The Pentagon
Washington, DC 20350-2000
Phone: (703) 695-4379
DSN: 225-4379

APPENDIX D
MARINE CORPS SOURCES OF INFORMATION FOR MODELING AND SIMULATION IN WEAPON SYSTEMS ACQUISITION

The information contained in this appendix draws heavily upon the list of organizations contained within the Marine Corps Modeling and Simulation Master Plan (Draft, dated 16 March 1994.

MARINE CORPS MODELING AND SIMULATION MANAGEMENT OFFICE (MCMSMO)

The MCMSMO is the focal point for modeling and simulation (M&S) in the Marine Corps. It serves as the management and coordinating activity for all M&S related activities and provides limited technical support to M&S users. The MCMSMO supports development of and manages the Marine Corps Modeling and Simulation Master Plan and long range investment strategies. The point of contact (POC) is:

MCCDC, T&E Div, MCMSMO (Code: C46MS)
2006 Hawkins Ave
Quantico, VA 22134
Phone: (703) 640-2520

Training and Education (T&E) Division, MCCDC: The T&E division is responsible for the development and implementation of policy and programs for training and education of all regular and reserve Marine Corps personnel and units. They function, among other things, as the proponent for non-standard training devices and simulators, validate training device requirements, and develop and refine the Marine Corps Ground Range Program. This division also functions as the proponent for MTWS and provides constructive modeling support to the Fleet Marine Force (FMF), Marine Corps University (MCU) and other agencies. The POC is:

MCCDC, T&E Div (Code: C46)
1019 Elliot Rd.
Quantico, VA 22134
Phone: (703) 640-3731

Marine Corps Operational Test and Evaluation Activity (MCOTEA): The MCOTEA is the Marine Corps principal operational test organization. The MCOTEA is an active member of the MCMSWG and provides the necessary test perspective to Marine Corps

M&S policies, procedures and guidelines. The POC is:

MCCDC, MCOTEA
3035 Barnett Ave
Quantico, VA 22134
Phone: (703) 640-3141

Marine Corps Tactical Systems Support Activity (MCTSSA), Marine Corps Systems Command (MARCORSYSCOM): This activity supports tactical software development by conducting testing and providing maintenance through the software life cycle. The MCTSSA's integration of M&S in its testing process is a critical component in accomplishing many of the Marine Corps M&S end states. The POC is:

MARCORSYSCOM
MCTSSA
2033 Barnett Ave, Suite 315
Quantico, VA 22134-5010
Phone: (703) 640-3792
DSN: 278-2411

Amphibious Warfare Technology Directorate (AWT), MARCORSYSCOM: Research and demonstration of future technologies and their applicability to the Corps is the responsibility of AWT. A significant element in AWT activities is M&S related technology. The AWT also provides technology insights which support MCMSWG activities. The POC is:

MARCORSYSCOM
AWT
2033 Barnett Ave, Suite 315
Quantico, VA 22134-5010
Phone: (703) 640-3792
DSN: 278-2411

Wargaming and Combat Simulation Division (WCSD): The WCSD provides wargaming and assessment support for HQMC, the operating forces (active and reserve), and the supporting establishment including the Marine Corps Combat Development Command (MCCDC). The POC is:

MCCDC, WCSD, (Code: C471)
2076 South St.
Quantico, VA 22134
Phone: (703) 640-3276

MAGTF/Expeditionary Training Center (M/ETC): The M/ETC mission is to strengthen and improve the coordination and integration of training opportunities among MCAGCC, MAWTS, MWTC, LFTCs and other Service Training Centers in a Naval Expeditionary Warfare context. The M/ETC will compliment training through the use of models and simulators that support mission preview and rehearsal, and battle staff training. Additionally, M/ETC will use the Global Grid to participate in Joint and CINC level exercises and increase training opportunities for geographically dispersed active and reserve MAGTF elements. The POC is:

MCCDC, MSTP (C466)
2024 Barnett Ave, Suite 202
Quantico, VA 22134
Phone: (703) 640-3279
DSN: 278-3279

Marine Corps Computer and Telecommunications Activity (MCCTA), Headquarters Marine Corps (HQMC) (C4I2): The MCCTA is a major activity pursing and implementing Marine Corps requirements relating to establishing the Global Grid. Additionally, MCCTA participates in developing M&S verification, validation and accreditation (VV&A) and configuration management policies, procedures and guidelines as a member of the Marine Corps Modeling and Simulation Working Group (MCMSWG). The POC is:

CMC, HQMC
MCCTA
2 Navy Annex
Washington, DC 20380-1775
Phone: (703) 614-2443/2604
DSN: 224-2443/2604

ADS Demonstration Sites: Two ADS demonstration sites, the MCAGCC ADS Demonstration Site located at Twenty-nine Palms and the proposed DMSC at Quantico provide an operational setting to demonstrate and test M&S components. The POC is:

MCCDC, T&E Div, MCMSMO (Code: C46MS)
2006 Hawkins Ave.
Quantico, VA 22134
Phone: (703) 640-2498/2520
DSN: 278-2498

Program Support Directorate (PS), MARCORSYSCOM: The PS directorate is a matrix organization supporting the program manager (PM) in engineering, logistics, technical manual documentation, operations analysis and life cycle cost analysis. The PS has been designated the focal point for M&S within MARCORSYSCOM. The POC is:

MARCORSYSCOM
Program Support Directorate (Code: PSA)
2033 Barnett Ave., Suite 315
Quantico, VA 22134
Phone: (703) 640-4451
DSN: 278-4451

Deputy Chief of Naval Operations (Resources, Warfare Requirements and Assessment), Assessment Division, Assessments and Affordability Branch, Modeling and Analysis Section (N812D)

This office is the focal point for Navy modeling and simulation. The Navy M&S function is expected to transition to N6 during the summer of 1994. The POC is:

Chief of Naval Operations (N812D)
The Pentagon
Washington, DC 20350-2000
Phone: (703) 697-5242
DSN: 227-5242

Space and Naval Warfare Systems Command (SPAWAR 31)

SPAWAR 31 leads the Navy's M&S Technical Support Group. The POC is:

Commander, Space and Naval Warfare Systems Command, (SPAWAR 31)
2451 Crystal Drive
Arlington, VA 22245-5200
Phone: (703) 602-4540
DSN: 332-4540

USERS AND/OR DEVELOPERS

The following are users and/or developers of models and simulations. There may be a number of groups within each organization which deal with M&S. However, a single point of contact (code) is listed for each organization.

Naval Air Systems Command POC is:

Commander, Naval Air Systems Command
(PMA-205)
1421 Jefferson Davis Highway
Arlington, VA 22243
Phone: (703) 604-2245, ext.3046
DSN: 664-2245 ext. 3046

Naval Air Warfare Center/Aircraft Division (Warminster) POC is:

Commander, Naval Air Warfare Center/Aircraft Division (Code 30B)
PO. Box 5152
Warminster, PA 18974
Phone: (215) 441-1534
DSN: 441-1534

Naval Air Warfare Center/Aircraft Division (Patuxent River) POC is:

Naval Air Warfare Center/Aircraft Division
Flight Test and Engineering Group (Code SY02C)
Patuxent River, MD 20670
Phone: (301) 826-6009
DSN: 326-6009

Naval Air Warfare Center/Training Systems Division POC is:

Commander, Naval Air Warfare Center/Training Systems Division
(Code PDB8)
12350 Research Parkway
Orlando, FL 32826
Phone: (407) 380-8367
DSN: 960-8367

Naval Air Warfare Center/Weapons Division POC is:

Commander, Naval Air Warfare Center/Weapons Division
(Code C0243)
China Lake, CA 93555
Phone: (619) 939-2353
DSN: 437-2353

Naval Sea Systems Command POC is:

Commander, Naval Sea Systems Command
(SEA-91W1, Combat Systems Training)
2351 Jefferson Davis Highway
Arlington, VA 22242-5160
Phone: (703) 602-1782
DSN: 332-1782

Naval Surface Warfare Center/Headquarters POC is:

Commander, Naval Surface Warfare Center
(NSWC-04M)
2531 Jefferson Davis Highway
Arlington, VA 22242-5160
Phone: (703) 602-0632
DSN: 332-0632

Naval Surface Warfare Center/Carderock Division POC is:

Naval Surface Warfare Center/Carderock Division
(Code 21)
Bethesda, MD 20084-5000
Phone: (301) 227-1013
DSN: 287-1013

Naval Surface Warfare Center/Crane Division POC is:

Naval Surface Warfare Center/Crane Division
(Code 604), Bldg. 2045
300 Highway 361
Crane, IN 47522-5001
Phone: (812) 854-3966
DSN: 482-3966

Naval Surface Warfare Center/Dahlgren Division POC is:

Naval Surface Warfare Center/Dahlgren Division
(Code A08)
Dahlgren, VA 22448-5000
Phone: (703) 663-7369
DSN: 249-7369

Naval Surface Warfare Center/Dahlgren Division/Coastal Systems Station POC is:

Commanding Officer, Naval Surface Warfare Center/
Dahlgren Division/Coastal Systems Station
(Code 04)
Panama City, FL 32407
Phone: (904) 234-4200
DSN: 436-4200

Naval Surface Warfare Center/Indian Head Division POC is:

Naval Surface Warfare Center/Indian Head Division
(Code 64C4)
Indian Head, MD 20640-5000
Phone: (301) 743-4397
DSN: 354-4397

Naval Surface Warfare Center/Port Hueneme Division POC is:

Naval Surface Warfare Center/Port Hueneme Division
(Code 4L12)
4363 Missile Way
Port Hueneme, CA 93043-4307
Phone: (805) 982-7023
DSN: 551-7023

Hydrodynamics/Hydroacoustics Technology Center (NAVSEA-03HT) POC is:

Carderock Division, NSWC
Building 17, Room 120
Bethesda MD 20084-5000
Phone: (301) 227-3827
DSN: 287-3827

Naval Command & Control and Ocean Surveillance Center/RDT&E Division POC is:

Commander, Naval Command & Control and Ocean Surveillance Center/
RDT&E Division
(Code 78)
San Diego, CA 92152
Phone: (619) 553-1637
DSN: 553-1637

Naval Undersea Warfare Center POC is:

Commander, Naval Undersea Warfare Center Detachment, New London
(Code 63)
39 Smith St.
New London, CT 06320
Phone: (203) 440-4059
DSN: 636-4059

Naval Research Laboratory POC is:

Commander, Naval Research Laboratory
(Code 5550)
4555 Overlook Drive, S.W.,
Washington, DC 20375
Phone: (202) 767-3162
DSN: 297-3162

COMOPTEVFOR POC is:

COMOPTEVFOR
(Code 332)
7970 Diven St.
Norfolk, VA 23505-1498
Phone: (804) 445-0292
DSN: 565-0292

Center for Naval Analysis POC is:

Center for Naval Analysis
4401 Ford Avenue
PO. Box 16268
Alexandria, VA 22302-0268
Phone: (703) 824-2352/2998
DSN: 289-2352

Naval Center for Cost Analysis POC is:

Naval Center for Cost Analysis
1111 Jefferson Davis Highway
Suite 400 West Tower
Arlington VA 22202-4306
Phone: (703) 604-0293
DSN: 664-0293

NAVY MODELING AND SIMULATION CATALOG

The Navy Modeling and Simulation Catalog contains information on a number of Navy models ranging from engineering to campaign level. The catalog focuses on models used for Joint Mission Area and Support Area Assessments performed by the Chief of Naval Operations. The POC is:

Space and Naval Warfare Systems Command
(SPAWAR 312)
2451 Crystal Drive
Arlington, VA 22245-5200
Phone: (703) 602-4541
DSN: 332-4541

DEPARTMENT OF THE NAVY DOCUMENTS

In addition to the DON Instructions on Modeling and Simulation described in Chapter 3, the following documents concerning acquisition and M&S may be useful to the reader.

OPNAV Instruction 5000.42D. (19 April 1993). *OPNAV Role and Responsibilities in the Acquisition Process*.

SECNAVINST 5000.2A. (9 Dec 92). *Implementation of Defense Acquisition Management Documentation and Reports.*

PRINCIPLES FOR VERIFICATION, VALIDATION, AND ACCREDITATION (VV&A) OF NAVY MANAGED MODELS AND SIMULATIONS (M&S), dated 15 December 1993, prepared by SPAWAR 31. This document identifies principles and techniques to enhance V&V of Navy managed models and simulations and describes methods to facilitate accreditation. It describes three levels of accreditation and discusses the requirements for each level, including model documentation, verification plans & tests, validation plans & tests, configuration management, data, and personnel qualifications.

APPENDIX E
DEPARTMENT OF THE AIR FORCE SOURCES OF INFORMATION FOR MODELING AND SIMULATION IN WEAPON SYSTEMS ACQUISITION

This appendix provides information regarding various Air Force organizations' M&S activities. It provides office symbols, phone numbers and addresses to assist users in making initial contact.

POLICY AND GUIDANCE

Headquarters U.S. Air Force, Directorate of Modeling, Simulations, and Analysis (HQ USAF/XOM): The HQ USAF/XOM promulgates Air Force M&S policy; publishes guidance and administers the development of AFPD 16-10, *Modeling and Simulation Management* (draft, May 1994), AFI 16-1001, *Verification, Validation, and Accreditation* (draft), and AFI 16-1002, *M&S Management* (draft). The HQ USAF/XOM is the single point of contact for M&S issues and activities within the Air Force. They also represent the Air Force in joint, multi-service and multi-agency M&S efforts.

POINTS OF CONTACT:

This list is a continuation of very good information provided in AFMCP 800-66, Atch 7, dated 1 July 1993. This pamphlet is also a good reference for specific model information; description, OPR and phone numbers. This list is not a complete listing of all M&S contacts, however, it is a good starting point in locating assistance.

HQ USAF/XOM Room 4C1059 1400 Air Force, Pentagon Washington D.C. 20330-1400	Phone: (703) 695-1835/1847 DSN: 225-1847 FAX: (703) 695-1161
HQ USAF/XOME Evaluation Support Division 624 9th Street NW, Suite 300 Washington D.C. 20001-6303	Phone: (202) 504-5333 DSN: 285-5333
HQ USAF/XOMT Technical Support Division (same address as XOME)	Phone: (202) 504-5339 DSN: 285-5339
HQ USAF/XOMW Warfighting Support Division (same address as XOME)	Phone: (202) 504-4441 DSN: 285-4441

AFSAA Room 1E388 Air Force Studies and Analysis 1400 Air Force, Pentagon Washington D.C. 20330-1400	Phone: (703) 695-9048 DSN: 225-9048

Other organizations with M&S experience:

HQ AFMC/XRX Director for Requirements 4375 Chidlaw Rd. Suite 6 Wright-Patterson AFB, OH 45433-5001	Phone: (513) 257-4914 DSN: 787-4914
HSC/XR (AFMC) Human Systems Center Brooks AFB TX 78235-5000	Phone: (512) 471-3406 DSN: 240-3406
SMC/XR (AFMC) Space & Missile Systems Center Los Angeles AFB CA 90009-2960	Phone: (310) 336-4613 DSN: 833-4613
ESC/XRP (AFMC) Electronic Systems Center Hanscom AFB MA 01731-5000	Phone: (617) 377-6554 DSN: 478-6554
ASC/XR (AFMC) Aeronautical Systems Center Wright-Patterson AFB OH 45433-5000	Phone: (513) 255-4656 DSN: 785-4656
Armstrong Laboratory (AFMC) Brooks AFB TX 78235-5000	Phone: (512) 471-2424 DSN: 240-2424
Phillips Laboratory (AFMC) Kirtland AFB NM 87117-6008	Phone: (805) 846-1737 DSN: 246-1737
Rome Laboratory (AFMC) Griffiss AFB NY 13441-5700	Phone: (315) 330-7701 DSN: 587-7701
Wright Laboratory (AFMC) Wright-Patterson AFB OH 45433-6553	Phone: (513) 255-4840 DSN: 785-4840
OAS/XR Office of Aerospace Studies Kirtland AFB, NM 87117-6008	Phone: (505) 846-8322 DSN: 246-8322

AFSPACECOM/CNA HQ Air Force Space Command Peterson AFB CO 80914-5001	Phone: (719) 554-5196 DSN: 692-5196
AFIC/DOA Air Force Intelligence Cmd Kelly AFB TX 78243-5000	Phone: (210) 977-2877 DSN: 969-2877
AFCC/XR HQ Air Force Communications Cmd Scott AFB IL 62225-5000	Phone: (618) 256-5541 DSN: 576-5541
ACC/XP-JSG HQ Air Combat Command Langley AFB VA 23665-5520	Phone: (804) 764-5751 DSN: 574-5751
AMC/XPY HQ Air Mobility Command Scott AFB IL 62225-5001	Phone: (618) 256-5560 DSN: 576-5560
ATC/XPC Air Training Command Randolph AFB TX 78150-5000	Phone: (210) 652-2640 DSN: 487-2640
AFOTEC/SAN AF Operational Test & Eval Ctr Kirtland AFB NM 87117-6008	 Phone: (505) 846-1357 DSN: 246-1357
AWS/XTX Air Weather Service Scott AFB IL 62225-5008	Phone: (618) 256-4598 DSN: 576-4598
STRATCOM/J53 HQ US Strategic Command Force Assessment Division Offutt AFB NE 68113-5001	Phone: (402) 294-2355 DSN: 271-2355
AFDTC/XRP AF Developmental Test Center Eglin AFB, FL 32542-5495	Phone: (904) 882-4188 DSN: 872-4188
AFFTC/XRX AF Flight Test Center Edwards AFB CA 93542-1036	Phone: (805)277-3837 DSN: 527-3837

AEDC/DOT Arnold Engineering Development Ctr Arnold AFB TN 37389-9011	Phone: (615)454-6508 DSN: 340-6508
HQ AFMC/STXP AFMC Science & Technology Directorate Wright-Patterson AFB OH 45433-5006	Phone: (513)257-7850 DSN: 787-7850
AFOSR/XPP Air Force Office of Scientific Research Bolling AFB DC 20332-0001	Phone: (202)767-6010 DSN: 297-6010
HQ AFMC/LGP AFMC Logistics Directorate Wright-Patterson AFB OH 45433-5006	Phone: (513)257-5610 DSN: 787-5610
OC-ALC/FMPM Oklahoma City Air Logistics Center Tinker AFB OK 73145-3056	Phone: (405)739-2519 DSN: 336-2519
OO-ALC/FMPM Ogden Air Logistics Center Hill AFB UT 84056-5038	Phone: (801)777-5851 DSN: 924-5851
SA-ALC/FMPB San Antonio Air Logistics Center Kelly AFB TX 78241-6435	Phone: (201)925-6726 DSN: 945-6726
SM-ALC/FMPM Sacramento Air Logistics Center McClellan AFB CA 95652-1060	Phone: (916)643-6162 DSN: 633-6162
WR-ALC/FMPX-1 Warner Robins Air Logistics Center Robins AFB GA 31098-1640	Phone: (912)926-3202 DSN: 468-3202
AGMC/FM(2) Aerospace Guidance & Metrology Ctr Newark AFB OH 43057-5260	Phone: (614)522-7643 DSN: 346-7643

CATALOGS/SOURCE DOCUMENTS:

Catalog of Simulation Models and Wargames Used for Unit and Leader Training.(1987). (2nd ed.) Orlando FL: Training and Performance Data Center.

Catalog of War Games, Training Games, and Combat Simulations.(1983). Washington DC: Deputy Under Secretary of the Army (Operations Research).

Department of Defense Catalog of Logistics Models.(1990). Fort Lee VA: Defense Logistics Studies Information Exchange.

1990 Catalog of Computer Simulation Tools.(1990). Washington DC: Air Force Center of Studies and Analysis.

Major Military Models Written in SIMSCRIPT II.5. (3rd ed.) La Jolla CA: C.A.C.I.

A Summary of Analysis Methodologies Used in the Directorate of Mission Analysis, (1987). Wright-Patterson AFB OH: Deputy for Development Planning, Aeronautical Systems Center.

Survey of Models/Simulations at RL (Rome Laboratory). (1986). Vol. 3. Griffiss AFB NY: Rome Air Development Center.

Science Advisory Board (SAB) ad-hoc Committee on Modeling and Simulation, December 1991.

Science Advisory Board (SAB) Report for Theater Missile Defense (TMD),(1993).

AFMCP 800-66. (July 1993). *AFMC Models and SimulationS (M&S) Guide.* Wright-Patterson AFB, OH: HQ Air Force Materiel Command.

HQ USAF/XOM. *Newsletter: Issues in Air Force Simulation and Analysis*, (January 1994).

APPENDIX F
ADDITIONAL SOURCES OF INFORMATION FOR MODELING AND SIMULATION IN WEAPON SYSTEMS ACQUISITION

This appendix provides information on the Modeling and Simulation Information System (MSIS) and the DoD Information Analysis Centers (IAC). These are additional sources of information which may assist program managers in their search for models, simulations or data.

THE MODELING AND SIMULATION INFORMATION SYSTEM

1. Name of System: Modeling & Simulation Information System (MSIS).

2. Proponent / Sponsor / Operator: Defense Modeling & Simulation Office (DMSO).

3. Purpose: Serve as an information clearing house for M&S and related information. Provide a means of disseminating and coordinating M&S related information.

4. System Contents: Menu driven system containing catalogs to provide summary information on models, simulations and applicable data (including the J-8 and Service specific catalogs); documents and reports pertaining to activities and developments in M&S along with related and supporting areas; glossary of terms; calendar of events; remote access to other M&S information repositories. Key word / topic search capability in catalogs and other modules. All data are unclassified, with unrestricted distribution. The system also provides a number of support utilities and functions, including e-mail.

5. Account Availability: Individuals with interests in Modeling & Simulation and related areas.

6. Requirements for Use: *Users must register (see POC information, below) to obtain an account on the system.* User must provide necessary hardware and software to communicate with the system, e.g., PC with modem and terminal emulation/communications software or workstation with internet access. Direct dial (703 area code) and tymnet (local number access, nation-wide) access are provided. Users may also connect over the internet via telnet. Users with systems running a gopher client may connect to the system through the gopher client. As of July 1994 there is no charge for connect time.

7. Point of Contact (POC) for information or user accounts:

Modeling and Simulation Information System
ATTN: Administrative Support
1901 N. Beauregard St., Suite 510, Alexandria, VA 22311
Phone: (703) 379-3770 Fax: (703) 379-3778
E-mail: dmso@dmso.dtic.dla.mil - e-mail

CATALOGS LISTED IN THE MSIS (AS OF JULY 1994):

1. J-8 Catalog of Models and Simulations (12th edition)

2. TRANSCOM System Model Catalog (Sep 89)

3. Catalog of War Games, Training Games and Combat Simulation

4. MOdels and Simulations: Army Integrated Catalog (MOSAIC) (Dec 93)

5. Navy's Catalog of Models and Simulations (5 Oct 93)

6. U.S. Air Force Rome Laboratory Models and Simulations Catalog (Oct 93)

7. DMSO - Catalogs of Models and Simulations

8. Institute for Simulation and Training (IST) Catalog of Models and Simulations Documents, Videos, Files, etc.

NOTE: The content and format of the entries in the individual catalogs vary.

THE DOD INFORMATION ANALYSIS CENTERS

The DoD IACs provide information to users which allows them to benefit from experiences of counterparts in comparable fields of endeavor, and increase productivity and quality of research.

The IACs are established under DoD Regulation 3200.12-R-2, Centers for the Analysis of Scientific and Technical Information, dated 17 January 1985. Their primary mission is to collect, analyze, synthesize and disseminate worldwide scientific and technical information in clearly defined, specialized fields or subject areas.

There are 26 IACs supported by DoD, maintaining comprehensive knowledge bases which include historical, technical, scientific and other data and information collected on a worldwide basis. Information collections include a wide range of unclassified, limited distribution and classified information appropriate to the requirements of sponsoring technical communities.

The IACs also collect, maintain, and develop analytical tools and techniques including data bases, models and simulations. Their collections and products represent intensive evaluation and screening efforts to create authoritative sources of evaluated data.

For the purposes of this guide, the subject matter covered by existing DoD IACs is related to military functions, roles/missions and to key technologies. Figures F-1 and F-2 display

IACs Associated with Military Missions/Functions

Military Missions/Functional Area of Potential User IAC	Nuclear Forces	Ground Forces	Naval Forces	Tactical Air Force	SOF	Intelligence	Communications	Logistics	Training	Installations
APMIAC (Airfields, Pavements, & Mobility)	●	●		●	●	●			●	
CBIAC (Chemical/Biological Warfare)		●	●	●	●	●	●	●	●	●
CEIAC (Coastal Engineering)		●	●		●	●				●
CIAC (Ceramics)			●	●	●	●	●	●		
CPIA (Chemical Propulsion)	●	●	●	●	●			●	●	
CRISTIAC (Cold Regions)	●	●	●	●	●					●
CSERIAC (Crew Systems Ergonomics)		●	●	●					●	
CTIAC (Concrete Technology)		●	●							●
DACS (Data Analysis Center for Software)		●	●	●	●	●	●	●		
DASIAC (Nuclear Effects)	●	●	●	●						●
GACIAC (Guidance & Control)	●	●	●	●	●	●			●	
HEIAC (Hydraulic Engineering)		●	●							●
HTMIAC (High Temperature Materials)	●	●	●	●					●	
IRIA (Infrared)		●	●	●	●		●	●		
MIAC (Metals)		●	●	●	●					
MMCIAC (Metal Matrix Composites)	●	●	●	●				●		
MTIAC (Manufacturing Technology)						●		●		●
NTIAC (Nondestructive Testing)		●	●	●	●	●		●		●
PLASTEC (Plastics)										
RAC (Reliability)			●	●	●	●	●	●	●	
SMIAC (Soil Mechanics)		●		●	●	●		●		●
SURVIAC (Survivability/Vulnerability)		●	●	●	●	●	●		●	
TWSTIAC (Tactical Warfare Simulation & Technology)		●	●	●	●	●	●	●	●	●

Figure F-1. IACs Associated with Military Missions/Functions

the association of each IAC based on this organization.

Figure F-1 maps DoD IACs for users based on military mission or function. The IACs are identified by their abbreviations, which will be expanded later in this appendix.

For example, a user involved in planning, analysis or acquisition in support of Special Operations Forces (SOF) will find IACs with a · in the column labeled "SOF" more likely (but not exclusive) providers of appropriate and useful information products and services.

IACs Associated with DoD Key Technologies

Key Technology Area of Interest to Potential User Interest	Computer	Software	Sensors	Communications Networking	Electronic Devices	Environmental Effects	Materials and Processes	Energy Storage	Propulsion and Energy Conversion	Design Automation	Human-System Interface
IAC											
APMIAC (Airfields, Pavements, & Mobility)						●			●		
CBIAC (Chemical/Biological Warfare)	●		●		●	●					●
CEIAC (Coastal Engineering)						●					
CIAC (Ceramics)			●		●		●		●		
CPIA (Chemical Propulsion)						●	●	●	●		
CRISTIAC (Cold Regions)		●		●					●		
CSERIAC (Crew Systems Ergonomics)		●	●	●	●					●	●
CTIAC (Concrete Technology)						●	●				
DACS (Data Analysis Center for Software)	●	●	●	●	●	●	●			●	●
DASIAC (Nuclear Effects)	●	●		●	●	●	●	●	●		
GACIAC (Guidance & Control)		●	●		●	●	●	●	●	●	
HEIAC (Hydraulic Engineering)						●					
HTMIAC (High Temperature Materials)		●	●		●	●	●		●		
IRIA (Infrared)	●	●	●		●	●	●	●		●	
MIAC (Metals)		●	●	●	●	●	●		●		
MMCIAC (Metal Matrix Composites)						●	●	●	●		
MTIAC (Manufacturing Technology)	●	●	●	●	●	●	●			●	●
NTIAC (Nondestructive Testing)	●		●				●				●
PLASTEC (Plastics)							●				
RAC (Reliability)	●	●			●	●	●			●	
SMIAC (Soil Mechanics)						●	●				
SURVIAC (Survivability/Vulnerability)		●	●		●	●	●	●	●	●	●
TWSTIAC (Tactical Warfare Simulation & Technology)	●	●	●	●	●	●	●	●	●	●	●

Figure F-2. IACs Associated with DoD Key Technologies

Although likely to find useful M&S products within the TWSTIAC, a user would also possibly find useful M&S products addressing survivability within the SURVIAC.

Figure F-2 illustrates the subject matter focus of IACs as they relate to DoD Key Technologies. Again, a · in a Key Technology column highlights areas of special interest or focus within the IAC program. A key feature of the DoD IACs is that they work together to ensure that user needs are met.

FEES FOR SERVICES

Financial support for basic IAC operations is provided by the Defense Technical Information Center (DTIC). However, the IACs offset costs incurred in collecting, analyzing and disseminating information by a service charge structure implemented in accordance with guidance provided by DoD. *However, no charges are incurred without the explicit agreement of the customer.*

CONTACTING THE DOD IACS

Users may contact the appropriate IAC(s) directly for specific information. For general information on the DoD IAC program, or for assistance in locating an IAC to service a particular need, users can contact:

Defense Technical Information Center
ATTN: DTIC-AI
Cameron Station
Alexandria, VA 22304-6145
Phone: (703) 274-6260
DSN: 284-6260
FAX: (703) 274-0980
E-mail: iac@dgis.dtic.dla.mil

ALPHABETIC LISTING OF DOD IACS

Airfields, Pavements and Mobility Information Analysis Center (APMIAC):

Subject coverage – Airfields, pavements, vehicle mobility, and terrain, as relevant primarily to military needs. Specific areas of vehicle on- and off-road mobility, ground flotation and terrain evaluation. The POC is:

Commander and Director
U.S. Army Engineer Waterways Experimentation Station
ATTN: CEWES/GM-L
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Phone: Tech/Biblio Inquiries:
Mobility/Terrain: (601) 634-2734
Airfields/Pavements: (601) 634-3304
Computerized Database/Library: (601) 634-4120
FAX: (601) 634-3068

Ceramics Information Analysis Center (CIAC)

Subject coverage – Source of engineering and technical data, and research and development information on monolithic ceramics and ceramic composites, hybrids, laminates and coatings used in Defense systems. The POC is:

CIAC/CINDAS
Purdue University
2595 Yeager Road
West Lafayette, IN 47906-1398
Phone: (317) 494-9393
FAX: (317) 496-1175

Chemical Propulsion Information Agency (CPIA)

Subject coverage – Acquisition, analysis and dissemination of information in the areas of missile, space and gun propulsion technology. Hardware of interest includes rocket motors, rocket engines, air breathing missile propulsion systems, electric and nuclear space propulsion systems, electric and conventional guns, gas generators, mines and torpedoes, and their inert and energetic components. The POC is:

The Johns Hopkins University
Chemical Propulsion Information Agency
10630 Little Patuxent Parkway, Suite 202
Columbia, MD 21044-3201
Phone: (410)992-7306
FAX: (410)730-4969

Chemical Warfare/Chemical and Biological Defense (CW/CBD) Information Analysis Center (CBIAC):

Subject coverage – DoD focal point for technical information related to CW/CBD. The CBIAC collects, analyzes, summarizes and stores CW/CBD information available from both domestic and foreign sources. The POC is:

Battelle Edgewood Operations
ATTN: CBIAC
2113 Emmorton Park Road, Suite 200
Edgewood, MD 21040-1037
Inquiries, Products, Publications: (601) 634-2734
FAX: (410) 676-9703

Technical Area Tasks: (410) 676-0200
FAX: (410) 676-8862

Coastal Engineering Information Analysis Center (CEIAC):

Subject coverage – Coastal engineering, coastal regions, beaches, shore erosion, coastal environments, oceanography, ocean waves tides, inlets and hydrodynamics. The POC is:

Commander and Director
U.S. Army Engineer Waterways Experimentation Station
ATTN: CEWES-CV-I
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Phone: (601) 634-2012
FAX: (601) 634-3433

Cold Regions Science and Technology Information Analysis Center (CRSTIAC)

Subject coverage – Hydrology, climatology, civil engineering, meteorology, military operations, mobility, construction, materials in cold temperatures and environmental issues relating to cold regions. The POC is:

U.S. Army Cold Regions Research and Engineering Laboratory
72 Lyme Road
Hanover, NH 03755-1290
Phone: (603) 646-4221
FAX: (603) 646-4712

Concrete Technology Information Analysis Center (CTIAC)

Subject coverage – Concrete, reinforced concrete, reinforcing materials, cements, mixtures, construction materials, loads (force), fracture (mechanics), deformation, degradation, chemical analysis, repair, evaluation, maintenance and rehabilitation. The POC is:

Commander and Director
U.S. Army Engineer Waterways Experimentation Station
ATTN: CEWES/SV-Z
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Phone: (601) 634-3264
FAX: (601) 634-3242

Crew Station Ergonomics Information Analysis Center (CSERIAC)

Subject coverage – Scientific and technical knowledge and data concerning human characteristics, abilities, limitations, physiological needs and tolerances, performance, body dimensions, biomechanical dynamics and physical strength. Also includes engineering and design data concerning equipment intended to be used, operated, maintained or controlled in sea, land, air and space environments. The POC is:

CSERIAC Program Office
AL/CFH/CSERIAC, Bldg 248
2255 H Street
Wright-Patterson AFB, OH 45433-7022
Phone: (513) 255-4842 or DSN 785-4842
FAX: (513) 255-4823 or DSN 785-4823

Data and Analysis Center for Software (DACS)

Subject coverage – Supports the development, testing, validation, transitioning of software engineering technology to the defense community, industry and academia. Includes the entire software life cycle (requirements definition, design, coding, integration, testing and post-deployment support). The POC is:

Data & Analysis Center for Software
Kaman Sciences Corporation
P.O. Box 120
Utica, NY 13503-0120
Phone: (315) 734-3696
FAX: (315) 734-3699

DoD Nuclear Information Analysis Center (DASIAC)

Subject coverage – Nuclear weapons explosion phenomena, effects on military strategic and tactical systems and components; survivability, vulnerability and hardening, military doctrine and operations, nuclear weapon effects testing. The POC is:

DASIAC
2560 Huntington Avenue, Suite 500
Alexandria, VA 22303-1490
Phone: (703) 960-4774
FAX: (703) 329-7198

Guidance and Control Information Analysis Center (GACIAC)

Subject coverage – Dissemination and exchange of technical information related to the guidance and control of weapons. These include missiles, rockets, bombs, submunitions, projectiles, mines and munition dispensing canisters. The POC is:

IIT Research Institute
GACIAC
10 West 35th Street
Chicago, IL 60616-3799
Phone: (312) 567-4345/4492
FAX: (312) 567-4889

High Temperature Materials Information Analysis Center (HTMIAC)

Subject coverage – Central source of engineering data and technical information on high temperature materials, properties and laser effects; especially in the critical technology areas of aerospace structural composites and metals, infrared detector materials and coatings. The POC is:

HTMIAC/CINDAS
Purdue University
2595 Yeager Road
West Lafayette, IN 47906-1398
Phone: (317) 494-9393
FAX: (317) 496-1175

Hydraulic Engineering Information Analysis Center (HEIAC)

Subject coverage – River, harbor and tidal hydraulics; flow through pipes, conduits, channels and spillways as related to flood control and navigation; hydraulic design and performance of dams, locks, channels and other structures. The POC is:

Commander and Director
U.S. Army Engineer Waterways Experimentation Station
ATTN: CEWES/HV-Z
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Phone: (601) 634-2608
FAX: (601) 634-4158

Infrared Information Analysis Center (IRIA)

Subject coverage – Electro-optics technology of interest to DoD including: sources of electromagnetic radiation from the ultraviolet through far infrared spectral regions; radiation characteristics of natural and man-made targets; optical properties of materials; detection materials and elements; information processing as it pertains to sensory collection of data; imaging, detecting, searching, homing, tracking and ranging subsystems. The POC is:

Environmental Research Institute of Michigan
ATTN: The IRIA Center
P.O. Box 134001
Ann Arbor, MI 48113-4001
Phone: (313) 994-1200 ext. 2302
FAX: (313) 994-5550

Manufacturing Technology Information Analysis Center (MTIAC)

Subject coverage – Collection, analysis and dissemination of manufacturing technology and data. Technology information is acquired in the following defense-related fields; machine tools and manufacturing equipment, robots and special machines, material handling equipment, controls, software and databases, communication lines and networks, sensors, inspection or checkout procedures, factory automation, computer-integrated manufacturing, specific defense-related products, and the management aspects of manufacturing technology. The POC is:

MTIAC
IIT Research Institute
10 West 35th Street
Chicago, IL 60616-3799
Phone: (312) 567-4732
FAX: (312) 567-4736

Metal Information Analysis Center (MIAC)

Subject coverage – Central source of engineering and technical data and research and development information on monolithic metals, metal alloys, intermetallic compounds and coatings used in defense systems. The POC is:

MIAC/CINDAS
Purdue University
2595 Yeager Road
West Lafayette, IN 47906-1398
Phone: (317) 494-9393
FAX: (317) 496-1175

Metals Matrix Composites Information Analysis Center (MMCIAC)

Subject coverage – Central source of engineering and technical data, and research and development information on metal matrix composites (MMC). Information pertaining to aspects of MMC applications in air, sea, land and space-based systems necessary for support of DoD basic and applied research. The POC is:

MMCIAC/CINDAS
Purdue University
2595 Yeager Road
West Lafayette, IN 47906-1398
Phone: (317) 494-9393
FAX: (317) 496-1175

Nondestructive Testing Information Analysis Center (NTIAC)

Subject coverage – Information pertaining to non-destructive testing, non-destructive evaluation, and non-destructive inspection. Coverage includes techniques and processes. The use of nondestructive sensors for manufacturing and materials process control, and for intelligent or adaptive control applications, is also within the purview of NTIAC. The POC is:

Texas Research Institute Austin
415A Crystal Creek Drive
Austin, TX 78746-6201
Phone: (512) 263-2106
FAX: (512) 263-3530

Plastics Technical Evaluation Center (PLASTEC)

Subject coverage – Acquisition, evaluation and exchange of technical information related to plastics, adhesives, and organic matrix composites. Coverage includes technology from applied research through fabrication, with emphasis on properties and performance. The POC is:

Plastics Technical Evaluation Center (PLASTEC)
U.S. Army Armament, Munitions and Chemicals Command
Picatinny Arsenal, NJ 07806-5000
Phone: (201) 724-4222/5859
FAX: (201) 361-7378

Reliability Analysis Center (RAC)

Subject coverage – Reliability, maintainability and quality of devices and systems. Reliability and failure mode/mechanism information that is generated during all phases of component fabrication, testing, equipment assembly and operation. Information and data include process control, quality assurance practices, screening and burn-in, qualification and environmental screening, failure analysis, reliability prediction and demonstrations, field testing and mission deployment. Reliability effects of electrical overstress and electrostatic discharge (EOS/ESD) on semiconductors is a specialty. The POC is:

Reliability Analysis Center (RAC)
IIT Research Institute
P.O. Box 4700
Rome, NY 13440-8200
Phone: (315) 337-0900
FAX: (315) 337-9932

Soil Mechanics Information and Analysis Center (SMIAC)

Subject coverage – Soil mechanics, engineering geology, rock mechanics, soil dynamics, earthquake engineering, earth and rockfill dams, levees, earth retaining structures and building foundations, and laboratory testing of soils and rocks. The POC is:

Commander and Director
U.S. Army Engineer Waterways Experimentation Station
ATTN: CEWES/GV-Z
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Phone: (601) 634-3376
FAX: (601) 634-3139

Survivability/Vulnerability Information and Analysis Center (SURVIAC)

Subject coverage – The DoD focal point for non-nuclear survivability/vulnerability data, information, methodologies, models and analyses relating to U.S. and foreign aeronautical and surface systems. Information and data covers the survivability of all allied and other non-adversary systems to threat weapons as well as the effectiveness of U.S. weapons against foreign systems. The POC is:

SURVIAC
Booz-Allen & Hamilton
WL/FIVS/SURVIAC
2130 Eighth St., Bldg 45, Suite 1
Wright-Patterson AFB, OH 45433-7542
Phone: (513) 255-4840/9509 or DSN 785-4840
FAX: (513) 255-9673 or DSN 785-9673

Tactical Warfare Simulation and Technology Information and Analysis Center (TWSTIAC)

Subject coverage – Principal focus is to meet operational requirements and the underlying acquisition and training needs associated with non-nuclear roles and missions for all tactical forces of the DoD. The *TWSTIAC is the DoD resource for assistance in developing and implementing M&S to operate in the DoD DIS environment. It is specifically mandated to perform primary research; develop and apply advanced and integrated M&S; develop standardized processes to collect, analyze, evaluate, and synthesize test data.* The POC is:

Battelle Memorial Institute
ATTN: TWSTIAC
505 King Avenue
Columbus, OH 43201-2693
Phone: (614) 424-5047
FAX: (614) 424-4874
Tactical Warfare Technology: (614) 424-7871
Distributed Interactive Simulation (DIS) and related
M&S information requirements: (407) 658-5014

MILITARY SERVICE-SPONSORED INFORMATION CENTERS

Several DoD components have established information centers which provide products and services comparable to those provided by the DoD IACs. Points of contact for these centers are provided below. Users should contact these organizations directly for further information.

U.S. Air Force Aerospace Structures Information Analysis Center (ASIAC):

Subject Coverage – A central agency for the collection and dissemination of information on aerospace structures. It provides state-of-the-art solutions to small complex structure problems and distributes structural computer programs not available at other dissemination centers. The POC is:

Aerospace Structures Information and Analysis Center
ATTN: WL/FIBRA/ASIAC
Wright-Patterson AFB, OH 45433-6553
Phone: (513) 255-6688 or DSN: 785-6688
FAX: (513) 476-4682

U.S. Navy Shock and Vibration Information Analysis Center (SAVIAC):

Subject Coverage – Research, analysis and testing related to the structural dynamics, mechanics and physical environmental effects on vehicles, structures, equipment, components and humans under operational and combat conditions. This encompasses technical areas of vibration, shock, blast, crash, impact, penetration, vibroacoustics and mechanical environments along with supporting areas of software, sensors, instrumentation and dynamic material properties. The SAVIAC operates under the direction of a multiple-agency Technical Advisory Group with members from the Army, Navy, Air Force, DNA, NASA and DOE laboratories. The POC is:

Shock and Vibration Information Analysis Center
2711 Jefferson Davis Highway #600
Arlington, VA 22202-4158
Phone: (703) 412-7570
FAX: (703) 412-6555

U.S. Air Force Supportability Investment Decision Analysis Center (SIDAC):

Subject Coverage: Acquire, improve and apply existing analysis methods, models, techniques and enabling services for all aspects of weapon system supportability. It focuses in the areas of logistics support, logistics research and development, technology insertion and supportability investment information. The POC is:

Supportability Investment Decision Analysis Center (SIDAC)
ATTN: SIDAC Program Director
Battelle Technical Support Operations, Dayton
5100 Springfield Pike, Suite 311
Dayton, OH 45431
Phone: (513) 258-6711 or 1-800-547-4322
FAX: (513) 254-9575

APPENDIX G
MODELING AND SIMULATION TEMPLATES FOR USE IN WEAPON SYSTEMS ACQUISITION ACTIVITIES

This appendix contains sample templates for the application of modeling and simulation (M&S) to some of the activities described in Chapter 5. These templates serve only as a general guideline to help acquisition managers in planning how they will use models and simulations in support of their programs. They are meant to stimulate ideas for planning and not to be directly applied to a particular program. The activities and M&S tools used will vary from one program to another. Therefore, such templates must be tailored specifically for each individual acquisition program including the specific models and simulations planned to support each activity or document preparation within the program. The functional activities addressed within this appendix include: requirements definition; program management; design and engineering; manufacturing; test and evaluation; training; and logistics support.

In these templates, readers will notice that models and simulations span across multiple phases of a program and that the same type of models and simulations are often used to support multiple acquisition activities. Recognizing this, acquisition managers should:

- Plan on M&S reuse to avoid duplicative M&S development efforts and to improve consistency across the acquisition process;

- Consider how the various functional disciplines can share the information from such models and simulations, to facilitate Integrated Product and Process Development (IPPD); and

- Plan for the transition of developmental models and simulations to support activities in later phases, such as to support weapon system upgrades or the training environment.

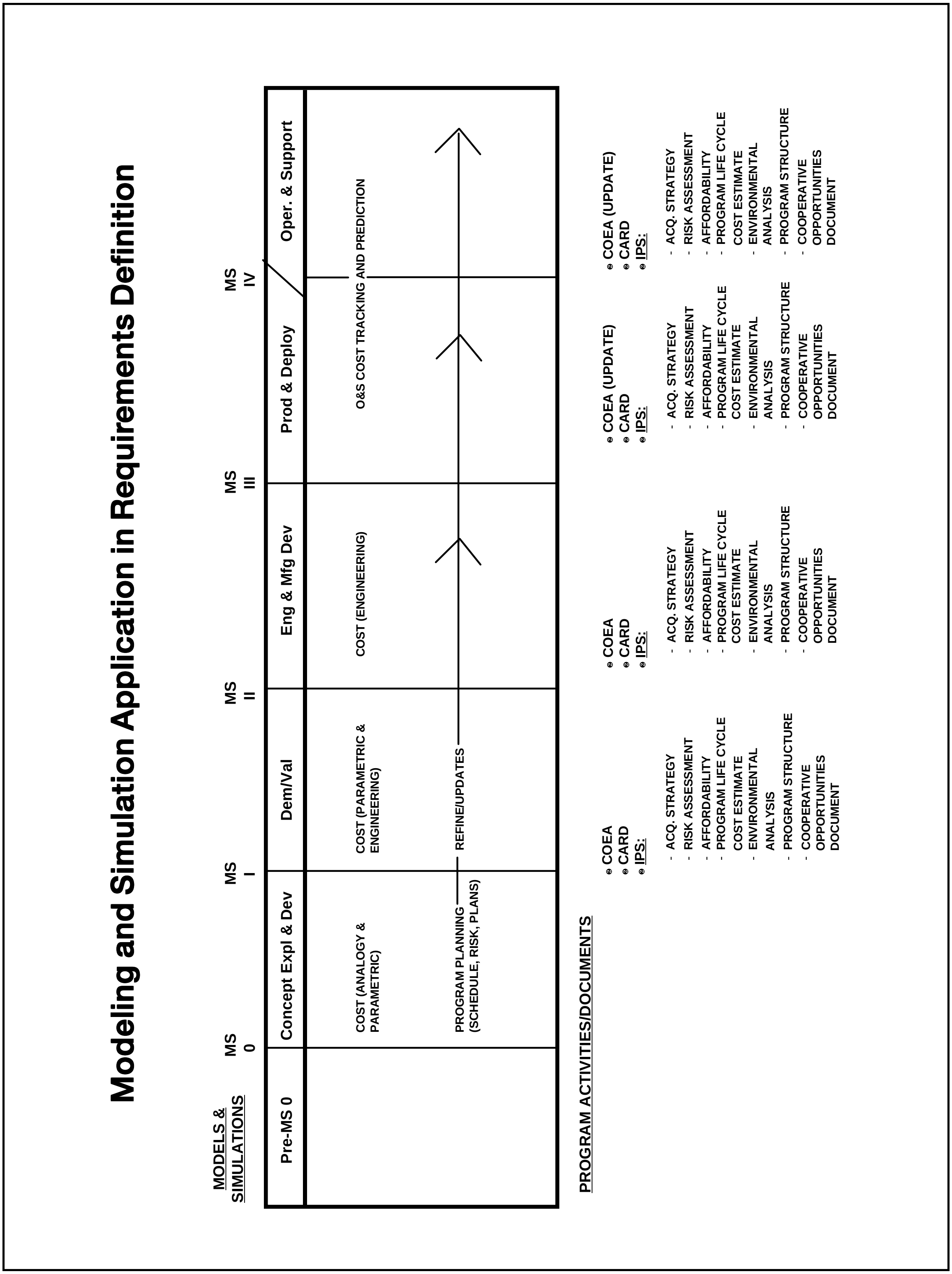

Figure G-1. Modeling and Simulation Application in Requirements Definition

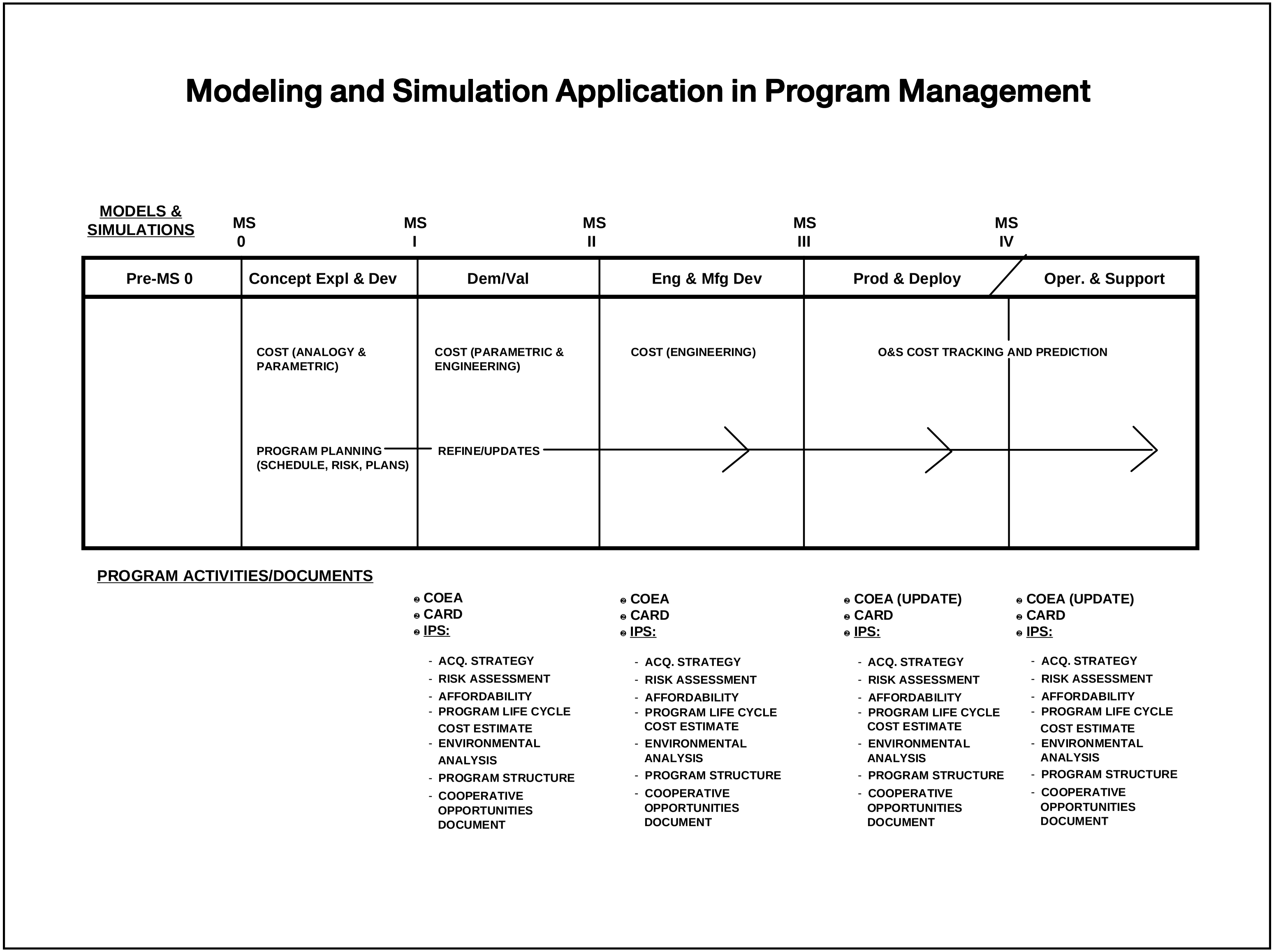

Figure G-2. Modeling and Simulation Application in Program Management

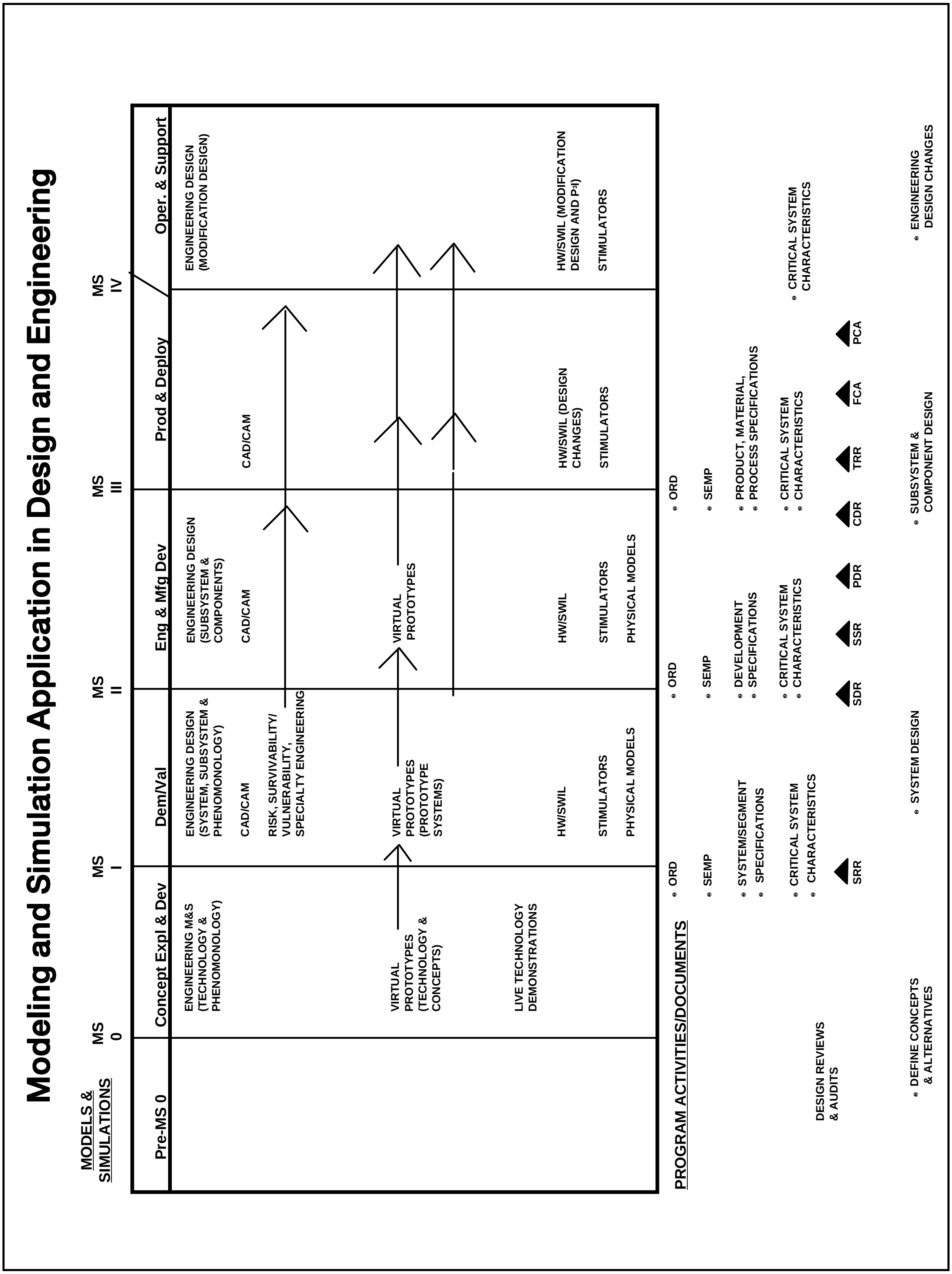

Figure G-3. Modeling and Simulation Application in Design and Engineering

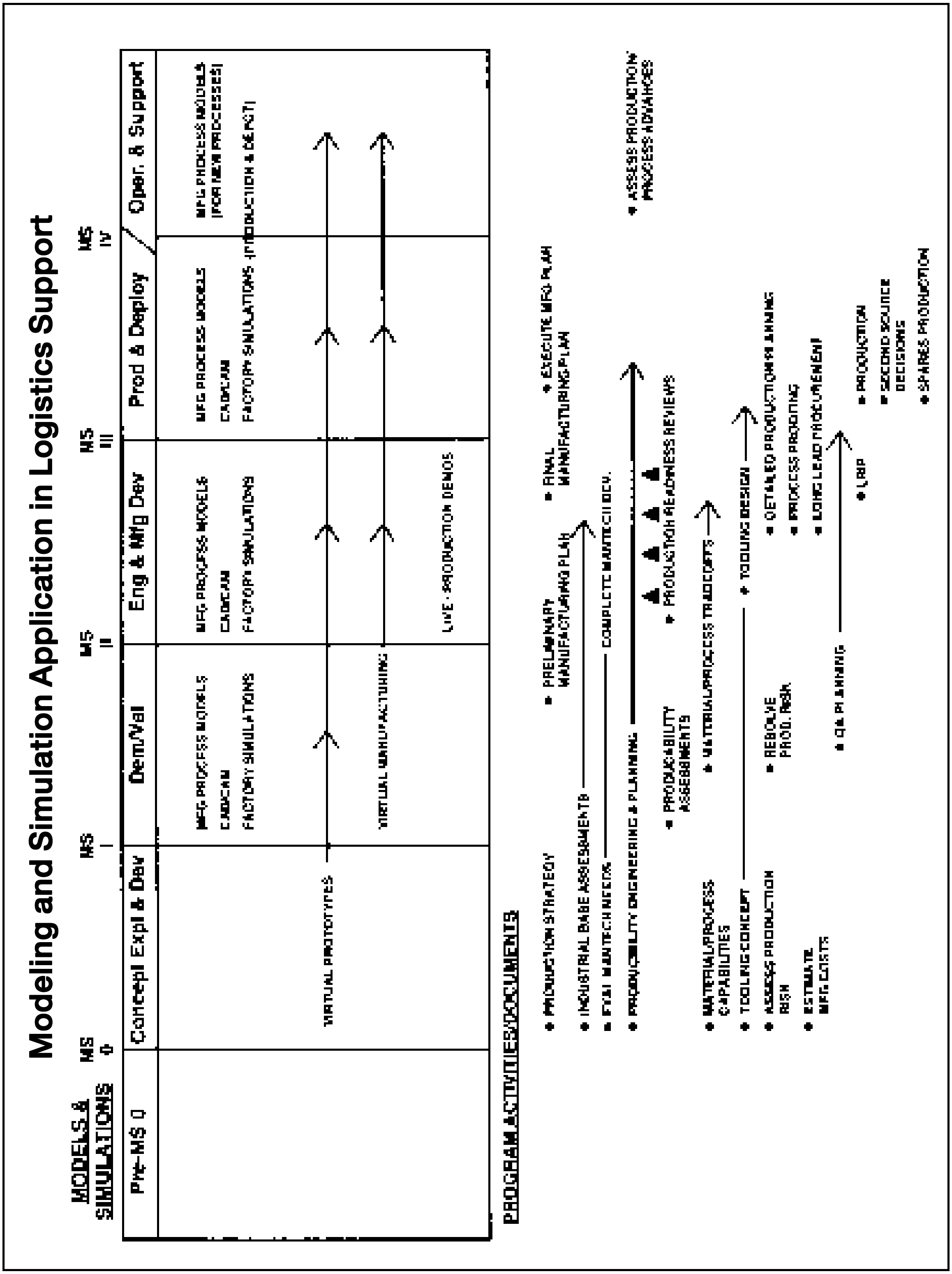

Figure G-4. Modeling and Simulation Application in Manufacturing

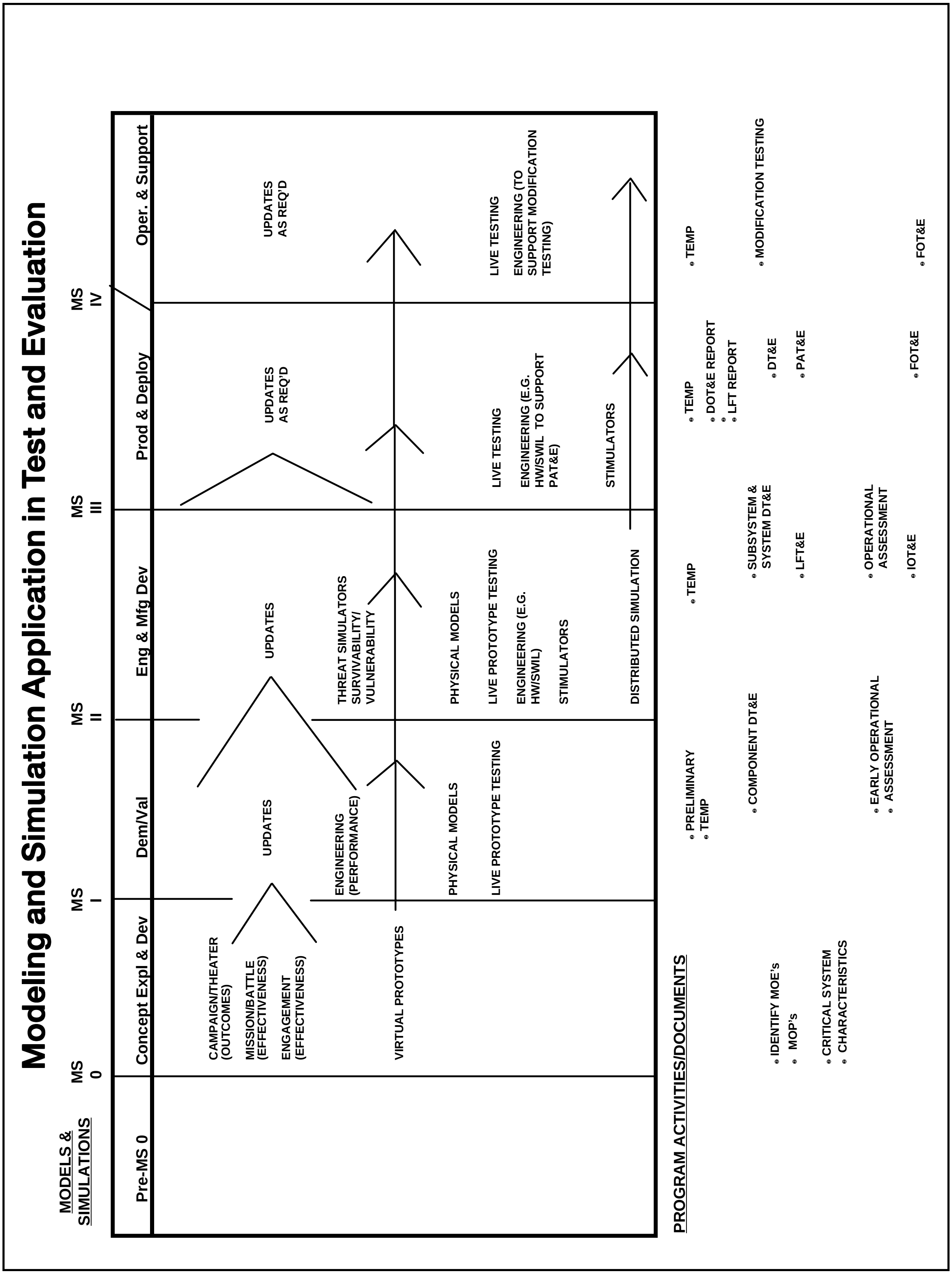

Figure G-5. Modeling and Simulation Application in Test and Evaluation

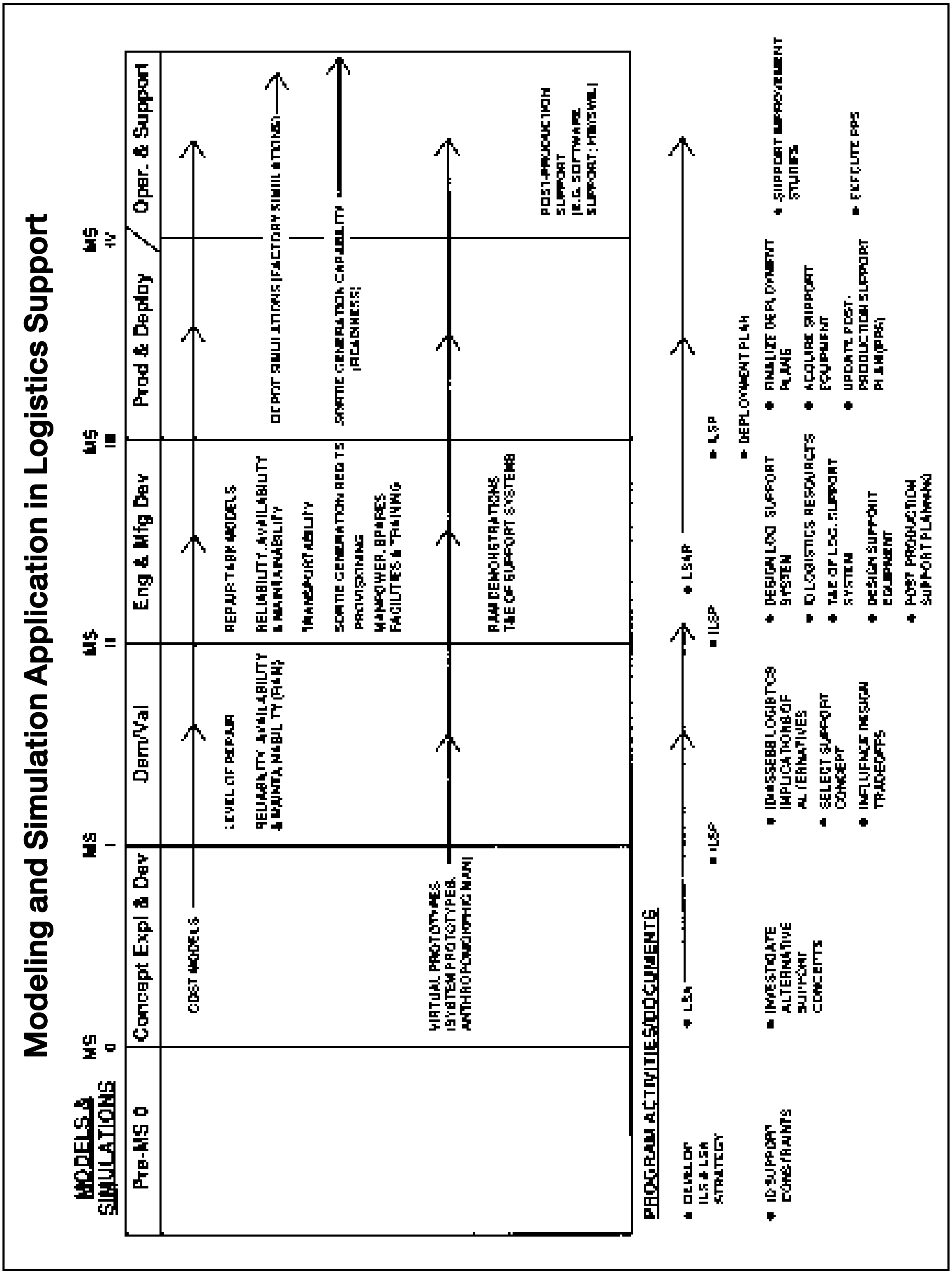

Figure G-6. Modeling and Simulation Application in Logistics Support

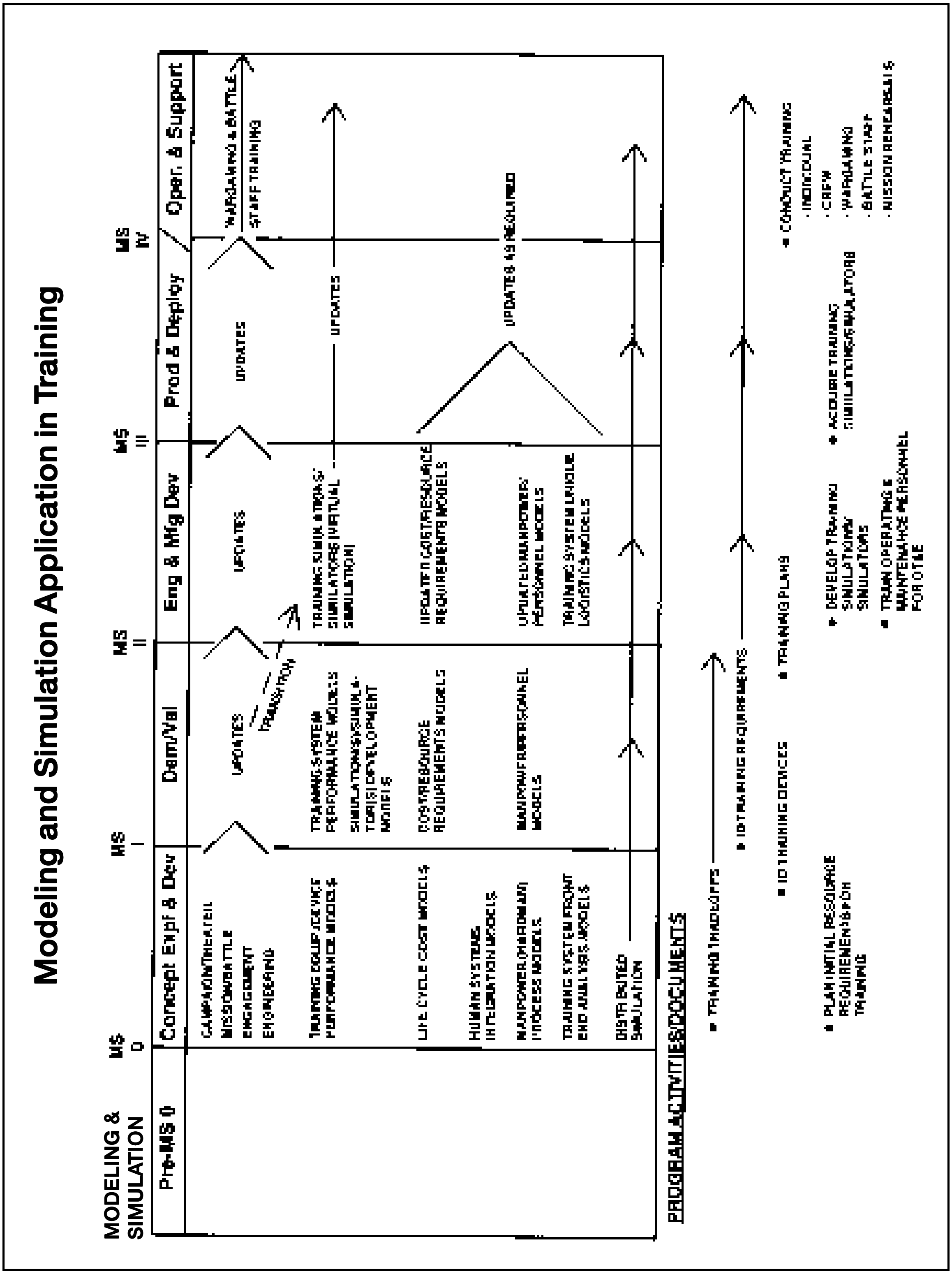

Figure G-7. Modeling and Simulation Application in Training

APPENDIX H
ABBREVIATIONS AND ACRONYMS USED THROUGHOUT THIS MODELING AND SIMULATION GUIDEBOOK

6-DOF	Six Degree-of-Freedom
ACAT	Acquisition Category
ACE-IT	Automated Cost Estimating - Integrated Tools
ACMC	Assistant Commandant of the Marine Corps
ADM	Acquisition Decision Memorandum
ADS	Advanced Distributed Simulation
AFAM	Air Force Acquisition Model
AFMC	Air Force Materiel Command
AFSAA	Air Force Studies and Analysis
ALM	Airlift Loading Model
AMC	Army Materiel Command
AMIP	Army Model Improvement Program
AMSAA	US Army Material Systems Analysis Activity
AMSEC	Army Modeling & Simulation Executive Council
AMSMO	Army Model & Simulation Management Office
AMSMP	Army Model & Simulation Management Program
AOR	Area of Responsibility
APB	Acquisition Program Baseline
APMIAC	Airfields, Pavements, and Mobility Information Analysis Center
AR	Army Regulation
ARPA	Advanced Research Projects Agency
ASD(PA&E)	Assistant Secretary of Defense (Program Analysis and Evaluation)
ASN(RDA)	Assistant Secretary of the Navy (Research, Development and Acquisition)
ATD	Advanced Technology Demonstrations
ATFM&S	Acquisition Task Force on Modeling & Simulation
AWC	US Army War College
AWSIM	Air Warfare Simulation Model
BAT	Brilliant Anti-Tank
BFTT	Battle Force Tactical Training
CAA	US Army Concepts Analysis Agency
CAAM	Composite Area Analysis Model
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CAIG	Cost Analysis Improvement Group
CALS	Continuous Acquisition and Life-cycle Support
CAM	Computer-Aided Manufacturing
CARD	Cost Analysis Requirements Document
CASTFOREM	Combined Arms and Support Task Force Evaluation Model

CATIA	Computer-aided Three Dimensional Interactive Application
CBIAC	Chemical Warfare/Chemical and Biological Defense Information Analysis Center
CCTT	Close Combat Tactical Trainer
CEAC	US Army Cost and Economic Analysis Center
CECOM	US Army Communications-Electronics Command
CED	Concept Exploration and Definition
CEIAC	Coastal Engineering Information Analysis Center
CEM V	Concepts Evaluation Model V
CIAC	Ceramics Information Analysis Center
CINC	Commander-in-Chief
CJCS	Chairman of the Joint Chiefs of Staff
CM	Configuration Management
COEA	Cost and Operational Effectiveness Analysis
CPIA	Chemical Propulsion Information Agency
CRSTIAC	Cold Regions Science and Technology Information Analysis Center
CSEAL	Combat System Engineering and Analysis Laboratory
CSERIAC	Crew Station Ergonomics Information Analysis Center
CTIAC	Concrete Technology Information Center
DA	Department of the Army
DAB	Defense Acquisition Board
DACS	Data and Analysis Center for Software
DAE	Defense Acquisition Executive
DASIAC	DoD Nuclear Information and Analysis Center
DDR&E	Director of Defense Research and Engineering
DDTO	Deputy Director of Technical Operations
DemVal	Demonstration and Validation
DepSecDef	Deputy Secretary of Defense
DIA	Defense Intelligence Agency
DIS	Distributed Interactive Simulation
DMS	Distributed Models and Simulations
DMSO	Defense Modeling & Simulation Office
DoD	Department of Defense
DON	Department of the Navy
DPG	Defense Planning Guidance
DSB	Defense Science Board
DSMC	Defense Systems Management College
DT	Developmental Test
DT&E	Developmental Testing and Evaluation
DTIC	Defense Technical Information Center
DUSA(OR)	Deputy Under Secretary of the Army for Operations Research
EADSIM	Extended Air defense Simulation
ECP	Engineering Change Proposal
EMD	Engineering and Manufacturing Development
ENWGS	Enhanced Naval Warfare Gaming System

EOS/ESD	Electrical Overstress and Electrostatic Discharge
ESAMS	Enhanced Surface-to-Air Missile Simnulation
EXCIMS	Executive Council on Modeling & Simulation
FMF	Fleet Marine Force
FOT&E	Follow-on Operational Test and Evaluation
GACIAC	Guidance and Control Information Analysis Center
GWEF	Guided Weapons Evaluation Facility
HQMC	Headquarters Marine Corps
HTMIAC	High Temperature Materials Information Analysis Center
HW/SWIL	Hardware/Software-In-The-Loop
HWIL	Hardware-In-the-Loop
IAC	Information Analysis Center
IDA	Institute for Defense Analysis
IG	Inspector General
IOT&E	Initial Operational Test and Evaluation
IPPD	Integrated Product and Process Development
IPR	In Process Review
IPT	Integrated Product Team
IRIA	Infrared Information Analysis Center
IWSM	Integrated Weapon System Management
JADS/JFS	Joint Advanced Distributed Simulation Joint Feasibility Study
JM&S	Joint Models and Simulations
JMSEP	Joint Modeling and Simulation Executive Panel
JROC	Joint Requirements Oversight Council
JTCG/AS	Joint Technical Coordinating Group on Aircraft Survivability
JTCTS	Joint Tactical Combat Training System
LAR	Launch Acceptability Regions
LCC	Life-Cycle Cost
LFT	Live Fire Testing
LMI	Logistics Management Institute
LOGSA	U.S. Army Materiel Command Logistics Support Agency
LORA	Level of Repair Analysis
LOS-F-H	Line-of-Sight Forward, Heavy
LRIP	Low Rate Initial Production
LSA	Logistics Support Analysis
LSAR	Logistics Support Analysis Records
M&S	Modeling and Simulation
M/ETC	MAGTF/Expeditionary Training Center
MAA	Mission Area Assessment
MAGTF	Marine Air-Ground Task Force
MAP	Mission Area Plan
MASS	Mobility Analysis Support System
MCCDC	Marine Corps Combat Development Command
MCMSMO	Marine Corps Modeling & Simulation Management Office

MCMSWG	Marine Corps Modeling & Simulation Working Group
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MIAC	Metals Information Analysis Center
MICOM	U.S. Army Missile Command
MMC	Metal Matrix Composites
MMCIAC	Metals Matrix Composites Information Analysis Center
MNA	Mission Need Analysis
MNS	Mission Need Statement
MOE	Measures of Effectiveness
MOO	Measures of Outcome
MOP	Measures of Performance
MOP 77	Memorandum of Policy No. 77
MOSAIC	MOdels & Simulations: Army Integrated Catalog
MOU	Memorandum of Understanding
MRS-BURU	Mobility Requirements Study-Bottom-Up Review Update
MS	Milestone (as in MS 0, MS I, etc.)
MS&A	Modeling & Simulation and Analysis
MSIS	Modeling and Simulation Information System
MTIAC	Manufacturing Technology Information Analysis Center
MTWS	Marine Air-Ground Task Force (MAGTF) Tactical Warfare Simulation
NAVAIR	Naval Air Systems Command
NDAA	Non-Developmental Airlift Aircraft
NDI	Non-Developmental Item
NLOS	Non Line-of-Sight
NTIAC	Nondestructive Testing Information Analysis Center
O&S	Operations and Support
OAS	Office of Aerospace Studies (Air Force Materiel Command)
OFP	Operational Flight Program
OPTEC	U.S. Army Operational Test and Evaluation Command
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT	Operational Test
OT&E	Operational Test and Evaluation
PA&E	Program Analysis and Evaluation
PDM	Periodic Depot Maintenance
PE	Program Element
PEO	Program Executive Office
PLASTEC	Plastics Technical Evaluation Center
PM	Program Manager
PMD	Program for Management Development
PMOs	Program Management Offices
PMWS	Program Manager’s Work Station
POC	Point of Contact

POM	Program Objective Memorandum
PPBS	Planning, Programming & Budgeting System
PRIMES	Preflight Integration of Munitions and Electronic Systems
R&D	Research and Development
RAC	Reliability Analysis Center
RAM	Reliability, Availability, and Maintainability
RCM	Requirements Correlation Matrix
RD&A	Research, Development and Acquisition
RDEC	Research, Development and Engineering Center
RFP	Request for Proposal
S&A	Studies and Analysis
SAB	Air Force Scientific Advisory Board
SAFMA	Strategic Airlift Force Mix
SAIC	Science Applications International Corporation
SEMP	Systems Engineering Management Plan
SIDAC	Supportability Investment Decision Information Analysis Center
SIMNET	Simulation Network
SIMTECH	Simulation Technology Program
SIMWG	Simulation Working Group
SMIAC	Soil Mechanics Information and Analysis Center
SOF	Special Operation Forces
SOW	Statement of Work
SPAWAR	Space and Naval Warfare Systems Command
SSP	Simulation Support Plan
SSTORM	Structured Scenario Torpedo Operational requirements Model
STAF	Simulation/Test Acceptance Facility
STRICOM	Simulation, Training and Instrumentation Command
SURVIAC	Survivability/Vulnerability Information Analysis Center
SYSCOM	Systems Command
T&E	Test and Evaluation
T&E	Training and Education Division, Marine Corps Combat Development Command
TACOM	U.S. Army Tank-Automotive Command
TARDEC	U.S. Army Tank Automotive and Armament Research, Development & Engineering Ctr
TECOM	U.S. Army Test and Evaluation Command
TEMP	Test and Evaluation Master Plan
TLD	Top Level Demonstrations
TPFDD	Time-Phased Force and Deployment Data
TPIPT	Technical Planning Integrated Product Team
TRAC	TRADOC Analysis Command
TRADOC	U.S. Army Training and Doctrine Command
TRIMS	Technical Risk Identification and Mitigation System
TWSTIAC	Tactical Warfare Simulation and Technology Information and Analysis Center

USAF/CVA	Assistant Vice Chief of Staff, U.S. Air Force
USAF/XOM	U.S. Air Force Directorate of Modeling , Simulation and Analysis
USD(A&T)	Under Secretary of Defense for Acquisition and Technology
USD(AR)	Under Secretary of Defense for Acquisition Reform
V&V	Verification and Validation
VV&A	Verification, Validation and Accreditation
WBS	Work Breakdown Structure
WEPTAC	Weapons and Tactics Center

APPENDIX I
GLOSSARY

Acceptability criteria: A set of standards that a particular M&S must meet to be accredited for a given use. (DA PAM 5-11)

Accreditation: The official certification that a model or simulation is acceptable for use for a specific purpose. (DoDD 5000.59)

Ada: A high order computer language designed and developed to DoD requirements for modular standard language. While the original focus was for real-time embedded software, Ada has also been used for a variety of other software systems including some simulation systems.

Advanced Distributed Simulation (ADS): A concept which applies a common core of advanced technologies (including; computer, display, communication and simulation) to provide a mix of live, constructive and virtual simulation methods across the spectrum of Defense uses, from training and readiness through requirements generation through prototyping through fielding. ADS and DIS are synonymous. (DSB)

Aggregate Level Simulation Protocol (ALSP): A protocol that permits the integration of distributed simulations (or Actors). The protocol is currently being used to integrate AWSIM and CBS. The protocol synchronizes the advancement of simulation time among the simulations, provides mechanisms for interaction among combat entities (e.g., direct or indirect fire engagements) across simulations, and the update of state attributes of those combat entities.

Air Warfare Simulation Model (AWSIM): The simulation currently used at the Warrior Preparation Center and Blue Flag to conduct battle staff training.

Algorithm: A prescribed set of well-defined, unambiguous rules or processes for the solution of a problem in a finite number of steps. (Webster Computer)

Appended Trainers: Combat Vehicle Appended Trainers are a family of deployable trainers designed to support individual and full-crew mission training for tanks, armored vehicles and assault vehicles. These trainers include the visual and aural cues which immerse the operator in a near-real battle environment, and have provisions for recording events for post-exercise crew performance analysis.

Architecture: The high-level organization of hardware or software systems. (Krueger)

Artificial Intelligence: The effort to automate those human skills that illustrate our intelligence (e.g., understanding visual images, understanding speech and written text, problem solving and medical diagnosis). (Krueger)

Brawler: TAC Brawler is an engagement level air-to-air combat simulation tool used primarily for the evaluation of avionics, weapons and tactics. It has also been used as a target generator for manned simulators. (J-8 Catalog).

C-Plus-Plus (C++): A high order computer language used extensively in commercial software. C++ is an object oriented extension to the C language.

Classes of Simulation:(DSB)

Live - The live component of simulation involves operations with real forces and real equipment in the air, on the ground, on and below the sea.

Constructive - A class of simulation typified by wargames, models and analytical tools.

Virtual - A class of simulation where systems are simulated both physically and electronically.

Code Verification: A rigorous audit of all compilable code to ensure that the representations of vertical logic have been properly implemented in the computer code. (DA PAM 5-11)

Combined Arms and Support Task force Evaluation Model (CASTFOREM): This is the Army's highest resolution, lowest echelon (up through and including brigade) combined arms combat simulation model. Often run in conjunction with JANUS(T) to perform weapon systems analysis for a COEA (MOSAIC).

Common-use M&S: M&S applications, services or materials provided by a DoD component to two or more DoD components. (DoDD 5000.59)

Compatibility: The capability of a functional unit to meet the requirements of a specified interface. (ANSI X3.172-1990)

Computer Generated Forces (CGF): A collection of unmanned battlefield entities under control as a unit. CGF replace or supplement friendly, enemy or neutral manned simulators during a specific session. The SIMNET program uses the term "semi-automated forces" (SAFOR) for CGF. (DIS Glossary)

Computer War Game: A technique by which different concepts, different pieces of hardware or different military plans can be investigated in a multi-sided confrontation using a computer to generate displays of the battlefield and perform computations of outcomes.

Concepts Evaluation Model (CEM): CEM is used to analyze force effectiveness at theater level warfare. It is used as a tool to assess the effectiveness of different mixes of forces or resources and estimates of ammunition, equipment and personnel requirements. (MOSAIC)

Concurrent Engineering: Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended from the outset to cause developers to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule and user requirements. (IDA)

Confederation of Models: A set of simulation methods (or Actors) operating in an integrated manner using the ALSP protocols.

Continuous System: A system for which the state variables change continuously with respect to time. (Law and Kelton)

Cooperative Development: A project in which two or more DoD components share in domain research, technical studies or technology development, but that may result in dissimilar M&S applications. (DoDD 5000.59)

Corps Battle Simulation (CBS): A simulation used by the Army simulation centers to train battle staffs at Corps and echelons below. Previously known as the Joint Exercise Simulation System (JESS).

Cross-functional Integration: The melding of acquisition functions (such as design analysis with logistics analysis) involving shared modeling and simulations data and information. (ATFM&S)

Data base Management System: A set of computer programs that provides convenient and efficient means to retrieve and store data in a database.

Data base: A collection of data.

Defense Simulation Internet (DSI): A communication network under development by ARPA that provides secure, packet-switched, data, voice and video services. Current system provides communication links at 1.5 megabits per second rates. DSI should not be confused with DIS: DSI may be used as a communication network over which DIS simulators are linked. However, DSI is not limited to supporting the linking of DIS simulators, nor are DIS simulators limited to using the DSI as a communication network.

Deterministic Algorithm: A process that yields a unique and predictable outcome for a given set of inputs. (Harris)

Discrete System: A system for which the state variables change instantaneously at separated points in time. (Law and Kelton)

Distributed Interactive Simulation (DIS): 1. A time and space coherent representation of a virtual battlefield environment, measured in terms of the human perception and the behaviors of warfighters interacting in free play with other warfighters and/or with computer generated forces. DIS provides a structure by which independently developed systems may interact with each other in a well managed and validated combat simulation environment during all phases of the development process and in subsequent training. DIS and ADS are synonymous. 2. The class of simulations defined by the DIS Architecture and associated standards. (DIS Glossary)

DoD Modeling and Simulation (M&S) Executive Agent: A DoD component to whom the USD(A&T) has assigned responsibility and delegated authority for the development and maintenance of a specific area of M&S application, including relevant standards and databases, used by or common to many models and simulations. (DoDD 5000.59)

Eagle: Corps/Division level combat model that simulates the operations level of war and includes joint and combined operations. It is used for assessments, combat development, as an exercise driver and as a staff trainer. (MOSAIC)

Enhanced Naval Warfare Gaming System (ENWGS): A multi-platform, multi-warfare, real-time wargaming and training simulation used for battle staff training and strategic and operational wargaming and planning. (Navy M&S Catalog)

Enhanced Surface-to-Air Missile Simulation (ESAMS): Generates one-on-one probability of kill for aircraft versus surface-to-air missiles. Its results are used in higher level survivability analyses to evaluate weapon system and subsystems effectiveness. (AFSAA Catalog)

Entity: An object by which the system can be defined (i.e., a component of the system represented in the model). (McQuay)

Executive Council for Modeling and Simulation (EXCIMS): An organization established by the Under Secretary of Defense (Acquisition) (USD(A)) (now USD(A&T)) and responsible for providing advice and assistance on DoD modeling and simulation issues. Membership is determined by the USD(A&T) and is at the Senior Executive Service, flag and general officer level. Chaired by the DDR&E. (DoD 5000.59)

Extended Air Defense Simulation (EADSIM): EADSIM is used primarily to analyze extended air-defense scenarios. It is used to evaluate effectiveness and efficiency of weapon systems against targets and to evaluate the value of different mixes of forces or resources. (J-8 Catalog)

Fidelity: The degree to which aspects of the real world are represented in the M&S. (See "Resolution")(DA PAM 5-11)

General-use M&S Applications: Specific representations of the physical environment effects used by, or common to, many models and simulations; e.g. terrain, atmospheric or hydrographic effects. (DoDD 5000.59)

Hardware/Software-in-the-Loop: This hybrid simulation includes actual system or subsystem hardware and software in conjunction with mathematical (computer) models and external stimuli to demonstrate the capability to operate within an environment simulating actual operating conditions.

Hierarchy: A hierarchy of models and simulations is a taxonomy which is used to describe the various levels of models and simulations. Assorted taxonomies may be found in the literature; this guidebook describes four levels of models and simulations: engineering, engagement, mission/battle and theater/campaign.

Hybrid Simulation: A simulation that combines multiple classes of simulations, such as combining computer (constructive) simulations with actual system hardware and software (live). An example is a hardware/software-in-the-loop simulation.

Integrated Product and Process Development (IPPD): IPPD is an approach to systems acquisition which brings together all of the functional disciplines required to develop, design, test, produce and field a system. This is essentially the same as Concurrent Engineering.

Integrated Product Team (IPT): Integrated Product Teams are a means to achieve concurrent engineering or IPPD. They are multidisciplinary teams consisting of representatives from all disciplines involved in the system acquisition process, from requirements development through disposal. Having the participation of all the appropriate disciplines, IPTs are often empowered to make decisions to achieve successful development of their particular product.

Interface: The interconnection between two pieces of hardware or software. A device or piece of software that accomplishes such a connection. (Krueger)

Interactive Models: Models that require human participation are sometimes called interactive or human-in-the-loop. Human participation can include decision making within computer wargaming models for tactics development and battle staff training as well as human-in-the-loop weapon system simulators and trainers.

Interoperability: The capability of two or more systems to exchange and use information. (ANSI X3.172-1990)

JANUS: JANUS is a multi-purpose near-real-time interactive wargame used to examine the relationships of combat and tactical processes. IT is used for weapon system performance, test planning, test augmentation, scenario evaluation and exercises. It can model entities down to the individual soldier or system. (MOSAIC)

Joint M&S: Modeling and simulation representations of joint and Service forces, capabilities, materials and services; used in the joint environment of by two or more Services. (DoDD 5000.59)

Legacy Model: A model developed in the past which is still in use that was not implemented using today's standards (e.g., software, communication, DIS, ALSP, etc.). Some legacy models have been modified with interfaces to some of the current standards extending their usefulness and interoperability with newer, standards based models.

Marine Air Ground Task Force (MAGTF) Tactical Warfare Simulation (MTWS): MTWS is a computer-assisted exercise support tool designed to support training of Marine Corps commanders and their staffs. It is designed to be used in Command Post Exercises in which combat forces, supporting arms, and combat results are modeled by the system. It will also be used in field exercises in which all, or part, of the combat forces are actual military units. MTWS provides a full spectrum of combat models required to support Marine Corps exercises.

Measure of Effectiveness (MOE): A quantitative expression which compares the effectiveness of alternatives in meeting an operational objective or need. (DA PAM 5-11)

Measure of Performance (MOP): A defined metric of a component which contributes to basic system effectiveness as described by an MOE. MOPs relate to specific performance characteristics from which data can be actually collected. (DA PAM 5-11)

Measures of Outcome (MOO): Metrics that define how operational requirements contribute to end results at higher levels, such as campaign or national strategic outcomes.

Model: A physical, mathematical or otherwise logical representation of a system entity, phenomenon or process. (DoDD 5000.59)

Model and Simulation (M&S) Interoperability: The ability of a model or simulation to provide services (data and functionality) to and accept services from other models and simulations; and to use the services so exchanged to enable them to operate effectively together. (DoDD 5000.59)

Modeling and Simulation (M&S) Investment Plan: A DoD plan, published under the authority of the Under Secretary of Defense (Acquisition & Technology) and with the coordination of the DoD components, that established short-term (present to six years) and long-term (beyond six years) programs and funding for joint and common use M&S to achieve the specified goals and objectives outlined in the DoD M&S Master Plan. (DoDD 5000.59)

Model-Test-Model: An integrated approach to using models and simulations in support of: pre-test analysis and planning; conducting the actual test and collecting data; and post-test analysis of test results along with further validation of the models using the test data.

Monte-Carlo Algorithm: A statistical procedure that determines the occurrence of probabilistic events or values of probabilistic variables for deterministic models, i.e., make a random draw. (Neelamkavil)

Object-Oriented Language: A language which best suits an object-oriented decomposition of software and which provides the capability to implement classes and objects. Directly supports data abstraction and classes, and provides additional support for inheritance as a means of expressing hierarchies of classes. (Booch)

Object-Oriented Programming: A method of implementation in which programs are organized as cooperative collections of objects, each of which represents an instance of some class, and whose classes are all members of a hierarchy of classes united via inheritance relationships. (Booch)

Object: Physical or logical structures (models) that keep their characteristics and behavior together.

Open System: A system in which the components and their composition are specified in a non-proprietary environment, enabling competing organizations to use these standard components to build competitive systems. There are three perspectives on open systems: portability-the degree to which a system component can be used in various environments, interoperability-the ability of individual components to exchange information, and integration-the consistency of the various human-machine interfaces between an individual and all hardware and software in the system. (Nutt)

Parallel Processing: Multiple processes running on multiple processors simultaneously.

Protocol: A set of rules used to control/regulate the interaction between entities in a system (e.g., computers communicating on a network). Often implemented as hierarchy of "layers" in which each level provides a defined set of services to the layer above.

Real-Time System: A system that computes its results as quickly as they are needed by a real-world system. Such a system responds quickly enough that there is no perceptible delay to the human observer. In general use, the term is often perverted to mean within the patience and tolerance of a human user. (Krueger)

Resolution: The degree of detail and precision used in representation of real world aspects in the M&S. (See "Fidelity) (DA PAM 5-11)

Requirements Correlation Matrix (RCM): A prioritized list of system requirements with associated performance thresholds and goals.

Semi-Automated Forces (SAFOR): Simulation of friendly, enemy and neutral platforms on the virtual battlefield in which the individual platform simulation are operated by computer simulation of the platform crew and command hierarchy. The term "semi-automated" implies that the automation is controlled and monitored by a human who injects command-level decision making into the automated command process. For the purpose of the DIS architecture, the term Computer Generated Forces (CGF) replaces SAFOR. (DIS Glossary)

Scenario: The entire spectrum of environmental considerations that have interaction with systems(s) under analysis or those of interest for training purposes. The spectrum includes physical environment, threat conditions, rules of engagements, and systems performance and effectiveness.

SIMNET: ARPA/Army simulation network where simulators can be connected over local and wide-area networks to create a simulated battlefield. SIMNET was the forerunner to the DIS architecture.

Simulation: A method for implementing a model over time. Also a technique for testing, analysis or training in which real-world systems are used, or where real-world an conceptual systems are reproduced by a model. (DoDD 5000.59)

State Variables: The collection of variables necessary to describe a system at a particular time, relative to the objectives of the study. (Law and Kelton)

Stimulation: Stimulation is the use of simulations to provide an external stimulus to a system or subsystem. An example is the use of a simulation representing the radar return from a target to drive (stimulate) the radar of a missile system within a hardware/software-in-the-loop simulation.

Stochastic Process: Any process dealing with events that develop in time or cannot be described precisely, except in terms of probability theory. (Webster Computer)

Stochastic: Probabilistic or random, as opposed to deterministic.

Structured Scenario Torpedo Operational Requirements Model (SSTORM): SSTORM is a high fidelity Monte-Carol torpedo simulation capable of modeling the performance of U. S. and threat weapons. It includes submarine and torpedo kinematics as well as countermeasures. (Navy M&S Catalog)

Synthetic Environments: Representations of present or future, factory-to-battlefield, environments generated by models, simulations and wargames. May include a mix of real and simulated objects accessible from widely dispersed locations. One of the Science and Technology Thrust areas.

Thunder: Thunder is a two-sided theater level model designed to simulate conventional, air-land combat. It determines contribution of weapon systems to the combat outcomes for key operational objectives. (AFSAA Catalog)

Virtual Prototype: A computer-based simulation of systems and subsystems which exhibits both geometric and functional realism. This three-dimensional *virtual mockup* may be used to evaluate prototypes or concepts and provides a common platform from which all functional disciplines (design, test, manufacturing, logistics, training, operations, etc.) can work.

Virtual Reality: 1. Also referred to as artificial reality or synthetic reality. Virtual reality perceives a participant's action in terms of the body's relationship to a graphic world and generates responses that maintain the illusion that his actions are taking place within that world. (Krueger) 2. The application of integrated technologies to enable a participant to sense that he or she is occupying, to some degree, an environment other than which he or she physically occupies. (Loftin)

Validation: The process of determining (a) the manner and degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model, and (b) the confidence that should be placed on this assessment. (DoDD 5000.59)

Verification: The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. (DoDD 5000.59)

Weapons and Tactics Center (WEPTAC): WEPTAC is an interactive wargaming model used for many-on-may, multi-platform scenarios. It is used for development of fleet tactics, as well as evaluating the military worth of future weapon systems. (Navy M&S Catalog)

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This research guidebook is to provide the reader with current DoD initiatives, policy and guidance, and identification of newly formed organizations in M&S. This book will provide a better understanding of how models are developed, applied in simulations and their value in analysis; and more importantly, it provides a quick reference for the application of these tools in the development of weapon systems. This guidebook offers lessons learned from current acquisition managers, advice on management practices, points of contact (POCs) and how to access M&S data bases.

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